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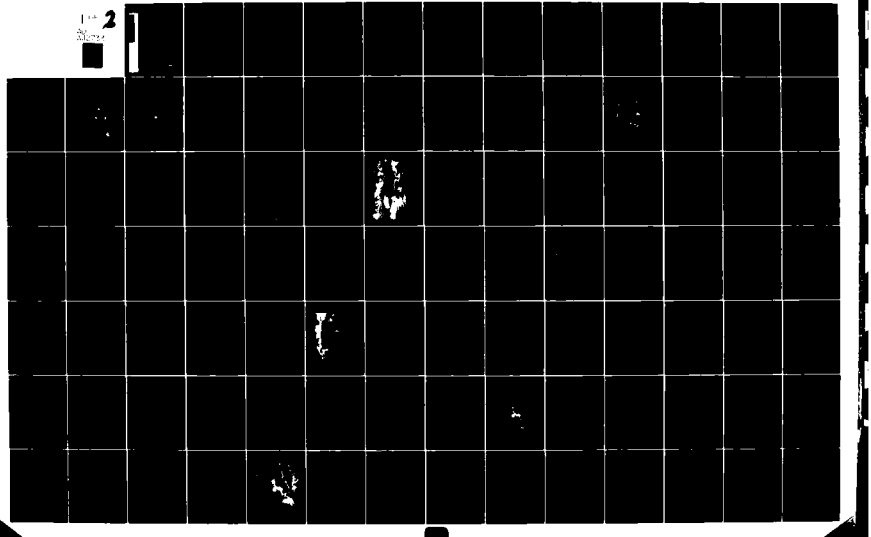

MX SITING INVESTIGATION
GEOTECHNICAL SUMMARY

PRIME CHARACTERIZATION SITES
GREAT BASIN
CANDIDATE SITING PROVINCE

PREPARED FOR

SPACE AND MISSILE SYSTEMS ORGANIZATION (SAMSO)

NORTON AIR FORCE BASE, CALIFORNIA

FUGRO NATIONAL, INC.
Consulting Engineers and Geologists

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: FN TR 26E	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Prime characterization sites Great Basin candidate siting province		5. TYPE OF REPORT & PERIOD COVERED: Final
		6. PERFORMING ORG. REPORT NUMBER: FN-TR-26E
7. AUTHOR(s): Fugro National, Inc.		8. CONTRACT OR GRANT NUMBER(s): F04704-77-C-0010
9. PERFORMING ORGANIZATION NAME AND ADDRESS: [illegible] (formerly, Fugro National) P.O. Box 7765 [illegible]		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 64313F
11. CONTROLLING OFFICE NAME AND ADDRESS: [illegible]		12. REPORT DATE: 15 Feb 79
		13. NUMBER OF PAGES: 82
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report): —
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Distribution Unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

~~Basin Configuration Geophysical properties Engineering,~~ construction considerations. Survey, [illegible], Drilling, [illegible], Seismic, [illegible] survey, [illegible] Seismic Refraction, [illegible]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of geotechnical field investigations performed in the Dry Lake & Delamar Valley characterization sites in central Nevada & the Sacramento Valley characterization site in northwestern Arizona.

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MX SITING INVESTIGATION
GEOTECHNICAL SUMMARY
PRIME CHARACTERIZATION SITES
GREAT BASIN
CANDIDATE SITING PROVINCE

Prepared for:

U. S. Department of the Air Force
Space and Missile Systems Organization
(SAMSO)
Norton Air Force Base, California 92409

Prepared by:

Fugro National, Inc.
3777 Long Beach Boulevard
Long Beach, California 90807

25 September 1978
15 February 1979 (rev.)

PRIME CHARACTERIZATION SITES
GREAT BASIN CSP

ERRATA

Replace the following figures with revised ones which accompany this sheet: Figures 5 (p. 16), 6 (p. 17), 11 (p. 36), 12 (p. 38), 17 (p. 55), and 18 (p. 57).

Replace the following tables with revised ones which accompany this sheet: Tables 5 (p. 19), 14 (p. 39), 23 (p. 58), and 24 (p. 59).

The following corrections are to be made to the original text:

page iii, List of Figures, Figure 2: Change "...Activities locations,..." to read "...Activity locations,..."

page iii, List of Figures, Figure 8: Change "...Activities locations,..." to read "...Activity locations,..."

page iii, List of Figures, Figure 14: Change "...Activities loctions..." to read "...Activity locations,..."

* page 3, paragraph 3, line 4: Change "...table..." to read "able"

page 4, line 9: Change "...Valleys..." to read "...valleys..."

page 4, line 13: Change "...sacle..." to read "...scale..."

page 6, Section 2.1, line 5: Change "...Tables 2 and 3..." to read "...Tables 2 and 3."

page 10, Figure 2: Generalized geologic map base revised, see Figure 5.

page 26, Section 3.0, line 4: Change "...bombing..." to read "...Bombing..."

* page 26, Section 3.1, line 3: Change "...is..." to read "...are..."

page 30, Figure 8: Generalized geologic map base revised, see Figure 11.

* page 35, last two lines: Remove the two words "...is bedrock..."

page 46, Section 4.0, line 5: Change "...state highway..." to read "...State Highway..."

* page 46, Section 4.0, line 6: Change word to read "...longitude..."

page 46, Section 4.0, Line 11: Change "...state highway..." to read "...State Highway..."

page 50, Figure 14: Generalized geologic map base revised, see Figure 17.

* page 51, paragraph 2, line 2: remove the word "...bouldery..."

* page 51, paragraph 2, line 5: Remove the comma.

page 56, Section 4.4, line 3: Change "...sionnal..." to "...sional..."

* page ~~61~~ 69, paragraph 1, line 14: Change sentence to read "...be able to..."

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* Corrections have already been made in some report copies.

FOREWORD

This report was prepared for the Department of the Air Force, Space and Missile Systems Organization (SAMSO) in compliance with conditions of Contract No. F04704-77-C-0010, and is a geotechnical summary of the three prime Characterization sites in the Great Basin Candidate Siting Province (CSP). The three sites are Dry Lake Valley and Ralston Valley, Nevada; and Sacramento Valley, Arizona.

The report presents representative data obtained from geotechnical field investigations performed at the three sites as part of the Characterization program. The information obtained from these studies, in combination with data obtained in the Screening studies, has been used for geotechnical ranking (FN-TR-25).

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1.0 INTRODUCTION

This report presents the results of geotechnical field investigations performed in the Dry Lake and Ralston Valley Characterization Sites in central Nevada and the Sacramento Valley Characterization Site in northwestern Arizona. This report presents representative data collected and analyzed for these sites. Access to the remaining data can be arranged through SAMSO/MNND, Norton Air Force Base, California.

The three sites are located in the Great Basin Candidate Siting Province (CSP), one of six provinces involved in the geotechnical Characterization studies. The location of the sites within the Great Basin CSP is shown in Figure 1. The Great Basin CSP is characterized by northeast to northwest trending elongate mountain ranges with intervening valleys. Most of the CSP lies within the state of Nevada, however, portions do extend into Utah, Arizona, California, and Idaho.

Suitable areas for deployment of MX missile systems remaining after Intermediate Screening were divided into CSPs based on similar geotechnical characteristics. The results of Intermediate Screening (FN-TR-17) indicated that existing data were not adequate in type or level of detail for follow-on geotechnical and geo-environmental evaluations, screening, site selection, and ranking studies. Therefore, the Characterization studies were developed to provide a rapid, relatively inexpensive method of gathering geotechnical data in a small area (maximum 700 nm^2; 2400 km^2) which is considered to be representative of a larger area within the CSP.

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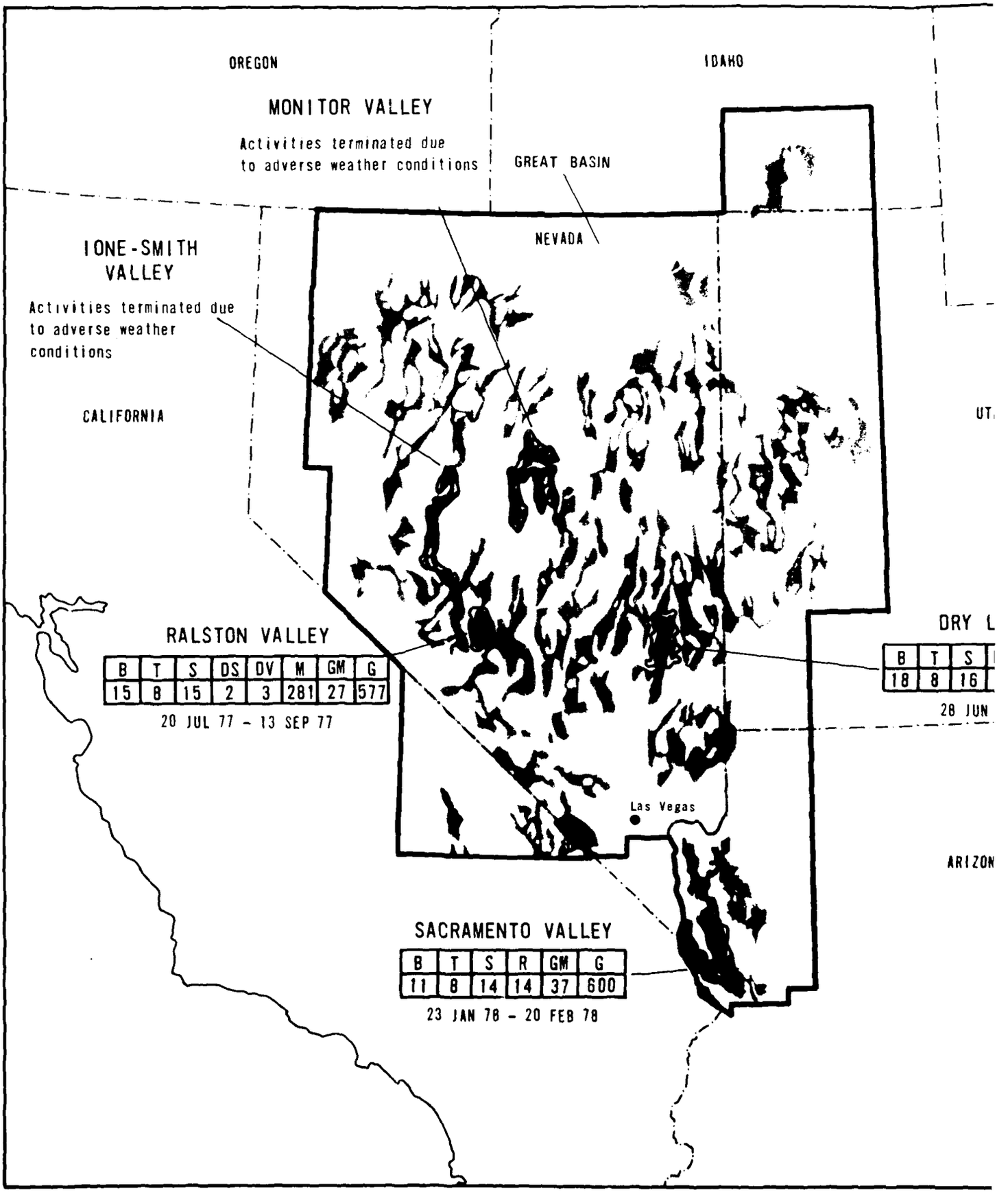
OREGON
IDAHO
MONITOR VALLEY
Activities terminated due to adverse weather conditions
GREAT BASIN
NEVADA
IONE-SMITH VALLEY
Activities terminated due to adverse weather conditions
CALIFORNIA
UT
RALSTON VALLEY
B T S DS DV M GM G
15 8 15 2 3 281 27 577
20 JUL 77 - 13 SEP 77
DRY L
B T S
18 8 16
28 JUN
Las Vegas
ARIZON
SACRAMENTO VALLEY
B T S R GM G
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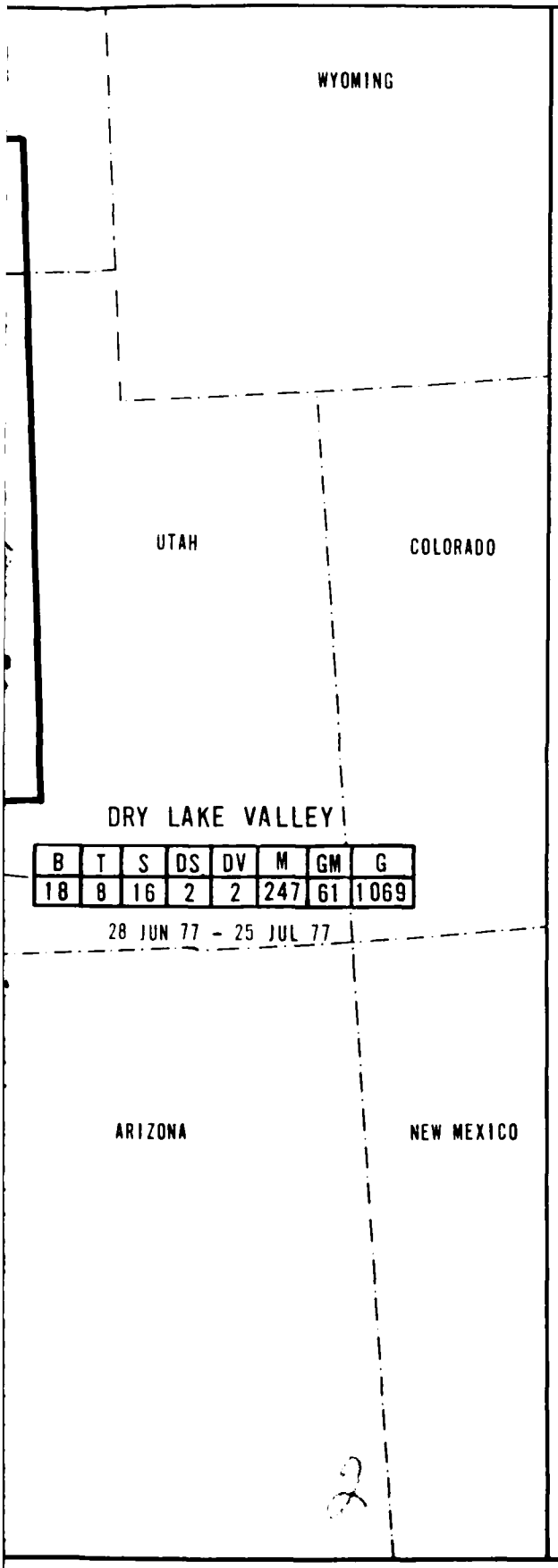
23 JAN 78 - 20 FEB 78



EXPLANATION

ACTIVITIES

B - BORINGS

T - TRENCHES

S - SHALLOW SEISMIC REFRACTION LINES

R - ELECTRICAL CONDUCTIVITY LINES

DS - DEEP SEISMIC REFRACTION LINES

DV - DOWNHOLE VELOCITY SURVEY

M - GROUND MAGNETIC STATIONS

GM - GEOLOGIC RECON MAPPING STATIONS

G - GRAVITY STATIONS

B	T
17	18

— Activity
— Quantity of each activity

SUITABLE AREA

PRIME SITE

SUPPLEMENTAL SITE

0 50 100 150 200
NAUTICAL MILES

0 50 100 150 200
STATUTE MILES

0 50 100 150 200
KILOMETERS

SCALE 1:5,000,000

CHARACTERIZATION SITES AND FIELD ACTIVITIES GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 1

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Emphasis was placed on the collection of information allowing characterization of geological units with respect to the construction aspects of MX missile basing options. Objectives of the Characterization studies were to obtain data that address the following geotechnical aspects:

- o Surficial geology and terrain
- o Subsurface conditions
- o Geophysical properties
- o Engineering properties

Although the program originally emphasized data collection for the trench and horizontal shelter basing modes, the data were utilized for evaluation of the vertical shelter basing mode as well. Characterization was, therefore, a refinement of the screening process whereby the necessary geotechnical information was developed to support the broader MX system design activities that were taking place concurrently and to provide a basis for geotechnical ranking of the CSPs for different basing modes.

Five Characterization sites (three prime and two supplemental) were selected in the Great Basin CSP (Figure 1), representing a total investigated area of less than ten percent of all suitable area within the CSP. Field activities in the two supplemental sites were terminated due to adverse weather conditions. Therefore only the three prime sites are discussed in this report. The Characterization Site selection process began with a delineation of geotechnically similar areas within each CSP having analogous depositional and geologic histories, rock and

water depths, and tectonic settings. Once these areas had been identified, non-geotechnical factors were applied to delineate the actual Characterization site boundaries. These non-geotechnical selection factors included access, proximity to support facilities, environmental sensitivities, and local logistical requirements.

Geologic, geophysical, and soils engineering techniques were used to determine the surface and subsurface geotechnical conditions in Dry Lake, Ralston, and Sacramento Valleys. These include a combination of the following:

- o Analysis of available data
- o Aerial photo interpretation of surficial geologic units utilizing black and white stereographic pairs at a ~~sacle~~ scale of approximately 1:60,000
- o Geologic field investigation to check aerial photo interpretation and to determine physical properties of the surficial units at selected field stations
- o Shallow and deep seismic refraction, downhole seismic velocity, and electrical conductivity surveys to obtain subsurface profile information
- o Gravity and ground magnetic surveys to aid in interpretation of basin configuration
- o Drilling and trenching to determine subsurface characteristics and obtain soil samples
- o Laboratory testing of soil samples to determine engineering properties

The Battle Mountain, Ely, and Kingman district offices of the U.S. Bureau of Land Management were contacted for access to the sites. Prior to initiating any field work, an archeological and environmental inspection was conducted at each site to ensure minimal impact to the local environment and to avoid damage to archeologic and historic sites. To further minimize potential impacts, all field activities were performed adjacent to existing roads or other previously disturbed areas.

2.0 DRY LAKE VALLEY SITE

The Dry Lake Valley Characterization Site covers an area of 251 nm^2 (861 km^2) in central Lincoln County, Nevada. The site is bounded by mountain ranges on the east, north, and west, and is open to Delamar Valley on the south. U. S. Highway 93 forms the southern boundary of the site and is the only paved road in the vicinity. A network of graded roads and four-wheel drive trails provide access within the site.

2.1 SCOPE OF INVESTIGATION

Scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site is presented in Table 1. Detailed information about the soils engineering field activities (18 borings and eight trenches) is summarized in Tables 2 and 3 Locations of all the field activities are shown in Figure 2.

2.2 SURFICIAL GEOLOGY AND TERRAIN

Alluvial fan deposits of younger and intermediate age are the predominant surficial geologic units within the Characterization site (Figure 2). The younger fan deposits cover approximately 42 percent of the area while the intermediate fan deposits cover 26 percent. Playa deposits cover approximately six percent of the surface. Although these playa deposits do not represent a large percentage of the surface area, they are generally of great thickness and interfinger with alluvial deposits in the subsurface. Playa deposits are located in the valley center with the alluvial fan deposits present between the playa and mountain fronts.

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geological mapping stations	61
Shallow refraction	16
Deep refraction	2
Downhole velocity	2
Gravity survey	1069
Ground magnetic stations	247

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
1	25 (8)
3	50 (15)
8	100 (30)
5	300 (91)
1	450 (137)
NUMBER OF TRENCHES	**NOMINAL DEPTH FEET (METERS)**
1	16 (5)
7	18 (6)

ENGINEERING–LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	362
Specific gravity	12
Sieve analysis	206
Hydrometer	99
Atterberg limits	121
Consolidation	4

TYPE OF TEST	NUMBER OF TESTS
Unconfined compression	13
Triaxial compression	10
Direct shear	4
Compaction	8
CBR	4
Chemical analysis	11

SCOPE OF FIELD AND LABORATORY ACTIVITIES
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 1

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BORING NUMBER	TOTAL DEPTH FEET(METERS)	TYPE OF DRILL RIG USED	TYPE OF SAMPLES* OBTAINED
DL-B-1	100.3(30.6)	Rotary Wash	SS
DL-B-2	100.9(30.8)	Rotary Wash	SS,B
DL-B-4	44.5(13.6)	Percussion	B
DL-B-5	300.4(91.6)	Rotary Air	P,B
DL-B-6	100.0(30.5)	Percussion	B
DL-B-7	95.0(29.0)	Percussion	B
DL-B-8	300.5(91.6)	Rotary Air/Wash	P,SS,B
DL-B-9	100.0(30.5)	Percussion	B
DL-B-10	23.0(7.0)	Percussion	B
DL-B-11	54.0(16.5)	Percussion	B
DL-B-12	300.0(91.4)	Rotary Air/Wash	P,SS,B
DL-B-13	302.1(92.1)	Rotary Air/Wash	P,SS,B
DL-B-14	47.0(14.3)	Percussion	B
DL-B-15	300.3(91.5)	Rotary Air/Wash	P,D,SS
DL-B-16	103.0(31.4)	Percussion	B,D
DL-B-17	100.0(30.5)	Percussion	B,D
DL-B-18	100.6(30.7)	Rotary Wash	P,B
DL-B-19	451.9(137.7)	Rotary Air/Wash	P,B

* P = Pitcher sample (undisturbed)
D = Fugro Drive sample (relatively undisturbed)
B = Bulk sample (disturbed, but representative)
SS = Split Spoon sample (disturbed, but representative)

ENGINEERING FIELD ACTIVITIES - BORINGS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 2

FUGRO NATIONAL, INC.

TRENCH NUMBER	TOTAL DEPTH FEET (METERS)	STABILITY OF VERTICAL EXCAVATION WALLS AND REMARKS
DL-T-1	18.0 (5.5)	0-10' (0-3.0m) stable 10-14' (3.0-4.3m) unstable; heavy sloughing into trench 14-18' (4.3-5.5m) stable; stage II caliche layer
DL-T-2	18.0 (5.5)	0-2' (0-0.6m) unstable 2-16' (0.6-4.9m) stable; stage III caliche layer at 12-14' (3.7-4.3m) 16-18' (4.9-5.5m) unstable; heavy sloughing into trench
DL-T-8	16.0 (4.9)	0-8' (0-2.4m) stable 8-14' (2.4-4.3m) unstable; heavy caving into trench 14-16' (4.3-4.9m) stable
DL-T-9	18.0 (5.5)	0-1' (0-0.3m) unstable 1-11' (0.3-3.4m) stable 11-15' (3.4-4.0m) unstable; sloughing into trench 15-18' (4.6-5.5m) stable
DL-T-11	18.0 (5.5)	0-3' (0-0.9m) unstable 3-18' (0.9-5.5m) stable
DL-T-12	18.0 (5.5)	0-6' (0-1.8m) unstable 6-18' (1.8-5.5m) stable
DL-T-15	18.0 (5.5)	stable
DL-T-17	18.0 (5.5)	unstable; heavy caving and sloughing. Trench was located in an active stream bed.

ENGINEERING FIELD ACTIVITIES - TRENCHES
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
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TABLE 3

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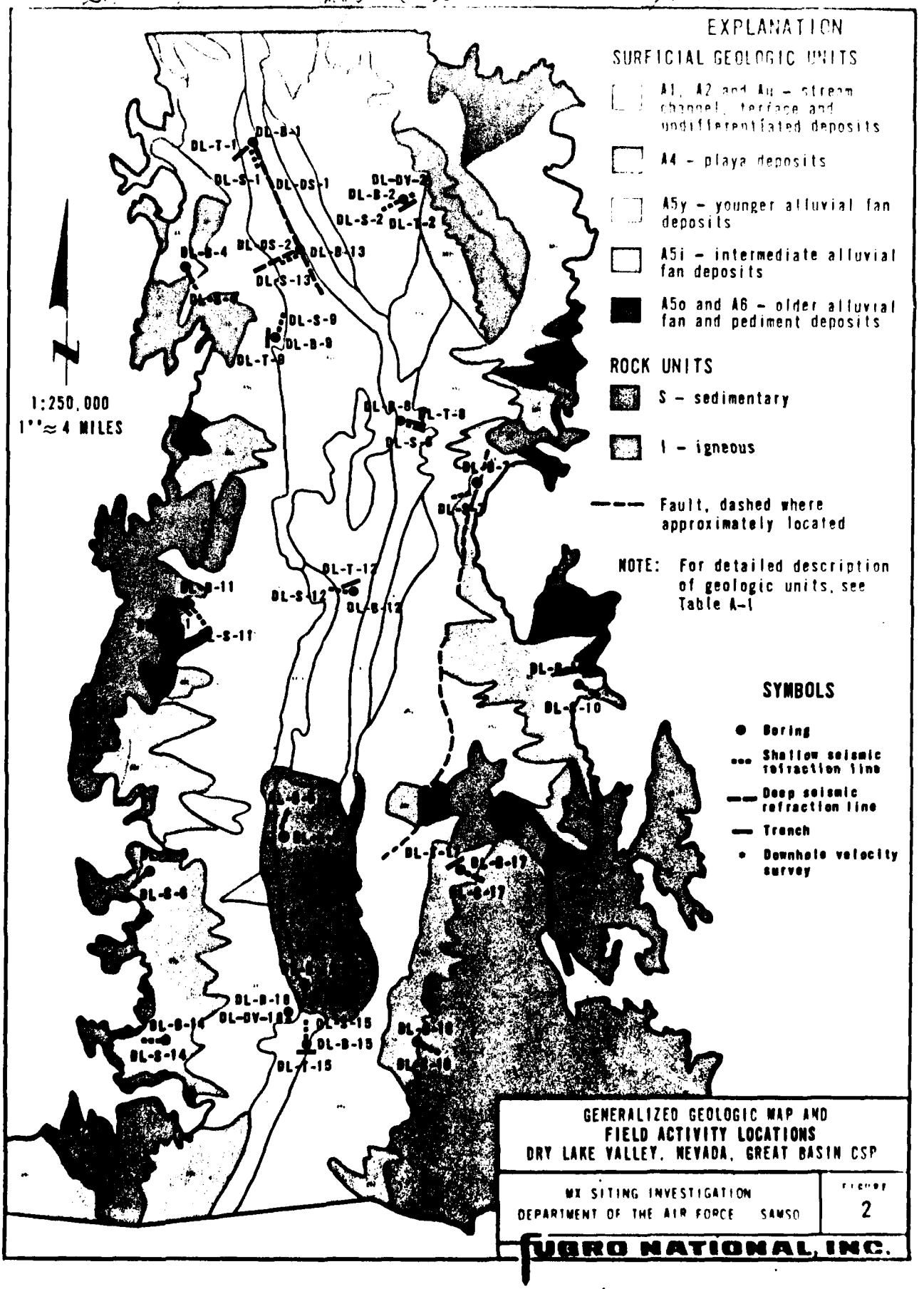
EXPLANATION
SURFICIAL GEOLOGIC UNITS
A1, A2 and Au – stream channel, terrace and undifferentiated deposits
A4 – playa deposits
A5y – younger alluvial fan deposits
A5i – intermediate alluvial fan deposits
A5o and A6 – older alluvial fan and pediment deposits
ROCK UNITS
S – sedimentary
I – igneous
Fault, dashed where approximately located
NOTE: For detailed description of geologic units, see Table A-1
SYMBOLS
Boring
Shallow seismic refraction line
Deep seismic refraction line
Trench
Downhole velocity survey
1:250,000
1"≈4 MILES
DL-T-1
DL-B-1
DL-S-1
DL-DS-1
DL-DV-2
DL-B-2
DL-S-2
DL-T-2
DL-B-4
DL-DS-2
DL-B-13
DL-S-13
DL-S-9
DL-B-9
DL-T-9
DL-B-8
DL-T-8
DL-S-8
DL-T-12
DL-S-12
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DL-B-11
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DL-B-10
DL-T-10
DL-B-6
DL-B-18
DL-DV-18
DL-S-15
DL-B-15
DL-T-15
DL-B-14
DL-S-14
DL-B-16
DL-T-16
DL-T-17
DL-B-17
DL-S-17
GENERALIZED GEOLOGIC MAP AND
FIELD ACTIVITY LOCATIONS
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO
FIGURE
2
FUGRO NATIONAL, INC.

The alluvial fan deposits are typically silty sands with gravel, ranging from sandy gravels near the mountain front to sandy silts near the playa. Playa deposits are generally clayey silts. These three units along with the remaining surficial units are described in Table 4.

Surface slopes and depths of drainage incision vary with geologic units, both generally increasing with proximity to the mountain fronts (Table 4). Maximum surface slope is ten percent with typical slopes of four percent. Maximum depths of incision (excluding older alluvial fan deposits) are 15 feet (5 m) with typical depths of five feet (1.5 m).

2.3 SUBSURFACE CONDITIONS

2.3.1 Soil Profiles

The composition of soils with depth is illustrated by the soil profiles shown in Figures 3 and 4. The dominant valley soils are silty sands and gravelly sands, which interbed with sandy gravels near the mountain fronts and clayey silts near the valley center. Cobbles and boulders are occasionally found near the mountain fronts and some plastic clays are encountered in the playas. Cementation of the soils varies with soil type and age, generally increasing with age of soil. Sandy soils with less than five percent fines were generally uncemented to weakly cemented, often caving in unshored trenches.

SURFICIAL GEOLOGIC UNIT (a)	GEOLOGIC AGE	THICKNESS FEET (METERS)	DESCRIPTIVE NAME(S)	USCS SYMBOL(S) (b)	AREAL EXTENT (SITE)		
					nm^2 (km^2)	PERCENT	GR
Undifferentiated Non-Rock Deposits (Au)	Quaternary-Tertiary	Unknown	Silty Sand with Gravel	SM	16 (55)	6	Pc
Fluvial Deposits (A1)	Holocene	Unknown	Silty Sand with Gravel	SM	24 (82)	10	Mo
Stream Terrace Deposits (A2s)	Holocene	Unknown	Silty Sand with Gravel	SM	16 (55)	6	Mo
Playa Deposits (A4)	Holocene	Unknown	Silty Clay Clayey Silt	CL, ML	11 (37)	4	
Older Playa and or Lacustrine Deposits (A4o)	Quaternary-Tertiary	Unknown	Clayey Silt	MH	5 (17)	2	
Younger Alluvial Fan Deposits (A5y)	Holocene	Unknown	Silty Sand with Gravel	SM	103 (353)	42	Mo
Intermediate Alluvial Fan Deposits (A5i)	Pleistocene	Unknown	Gravelly Silty Sand	SM	70 (241)	28	Mo w
Older Alluvial Fan Deposits (A5o)	Pleistocene	Unknown	Gravelly Silty Sand	SM	6 (21)	2	Mo wi

NOTES:

(a) For generic description of geologic units, see Table A-1.
(b) For description of USCS, see Table A-2.
(c) For description of stage of caliche, see Figure A-1.
(d) Mixed A1, A4, and A5 deposits.
(e) Includes three percent alluvial outwash deposits (Alw) which consists of mixed A1, A5y, and A5i deposits.
(f) Includes three percent mixed A4 and Au deposits; designated A4 Au on Figures 2 & 5
(g) Includes two percent of area underlain by shallow rock, designated A6 on Figures 2 & 5

REAL EXTENT (SITE)		PROPERTIES OF SURFACE MATERIALS					SURFACE MORPHOLOGY		NOTES
m^2 (km^2)	PERCENT	GRADATION	CEMENTATION	MAXIMUM GRAIN SIZE	PAVEMENT/ PATINA	STAGE OF CALICHE (c)	SLOPE (PERCENT)	DRAINAGE DEPTHS FEET(METERS)	
6 (55)	6	Poor-Well	Weak-Moderate	Cobble	None-Well/ None-Well	I-IV	<1-10	0-25 (0-8)	(d)
4 (82)	10	Moderately well	None	Cobble	None/None	None-I	<1	0-1 (0-0 3)	(e)
6 (55)	6	Moderately well	Weak	Cobble	Poor/ None-Poor	None-I	<1	0-15 (0-5)	
1 (37)	4	Poor	None-Weak	Sand	None/None	None-I	<1	0-2 (0-0 6)	(f)
5 (17)	2	Poor	Weak	Sand	None-Poor/ None-Poor	None-I	<1	0-5 (0-1 5)	
3 (353)	42	Poor-Moderately well	None-Weak	Cobble	None-Poor/ None-Poor	None-I	0-5	0-5 (0-1 5)	
(241)	28	Moderately well-Well	Weak-Moderate	Boulder	Poor-Well/ None-Fair	I-II	2-10	3-15 (1-5)	(g)
(21)	2	Moderately well-Well	Weak-Moderate	Boulder	Poor-Well/ Poor-Well	III-IV	5-10	5-25 (0-8)	

and A5i deposits.

DESCRIPTION OF SURFICIAL GEOLOGIC UNITS
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

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TABLE 4

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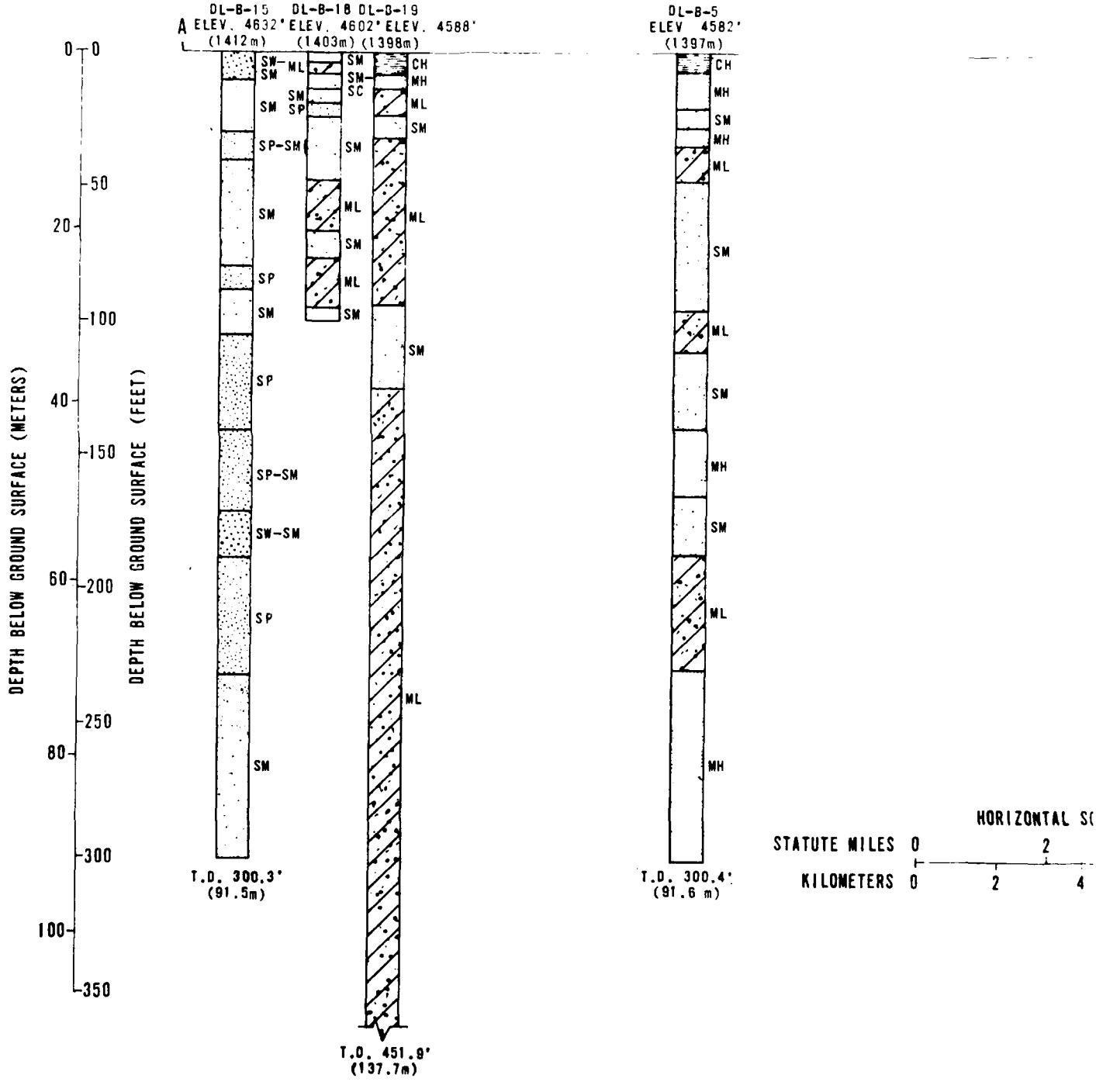
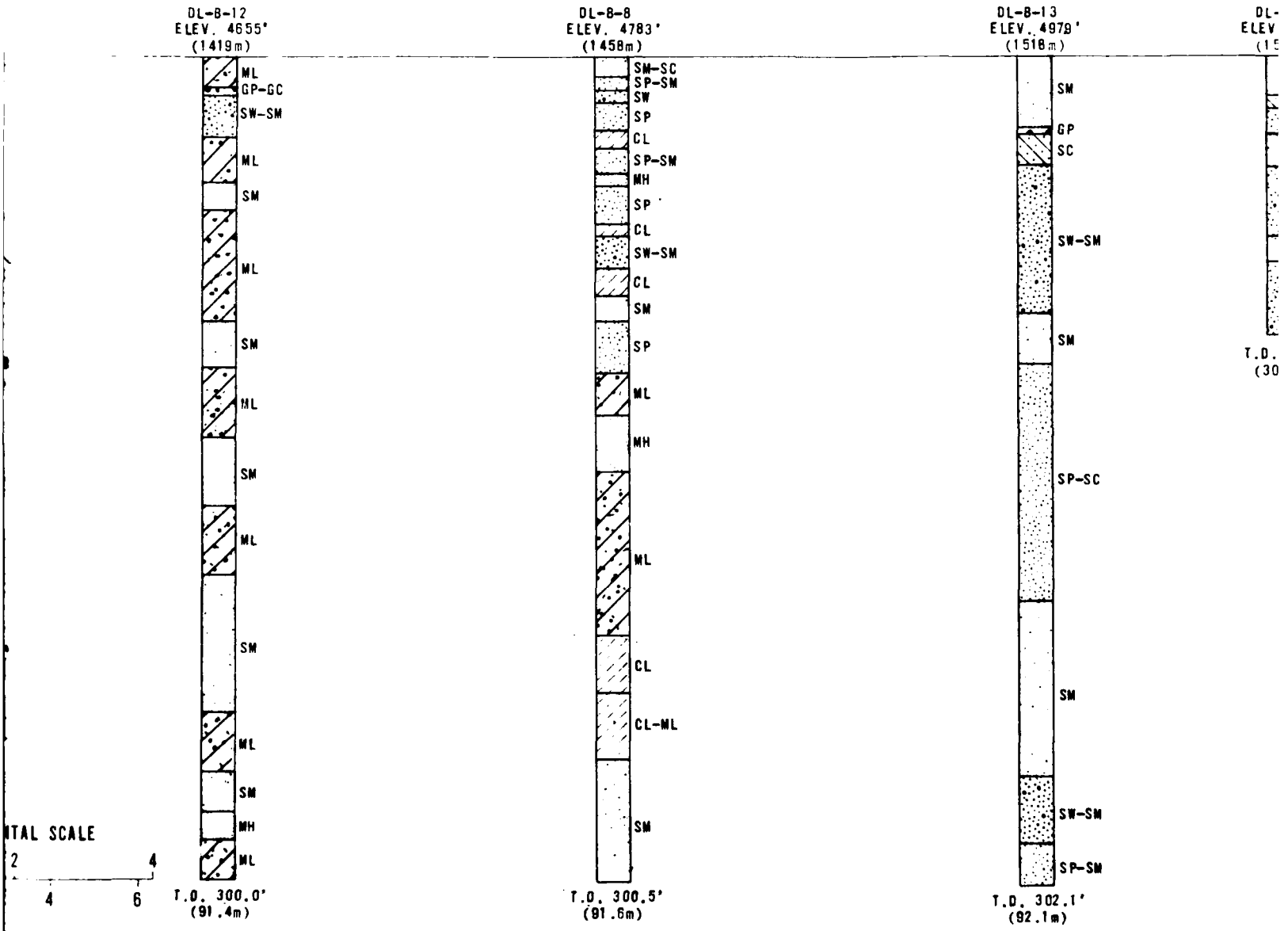
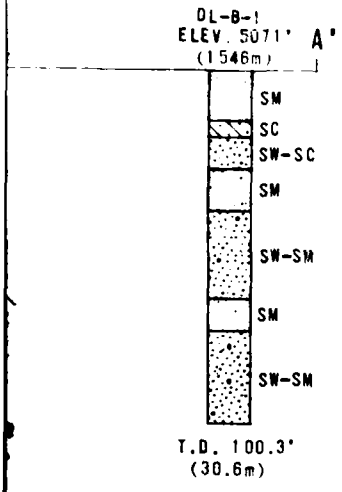
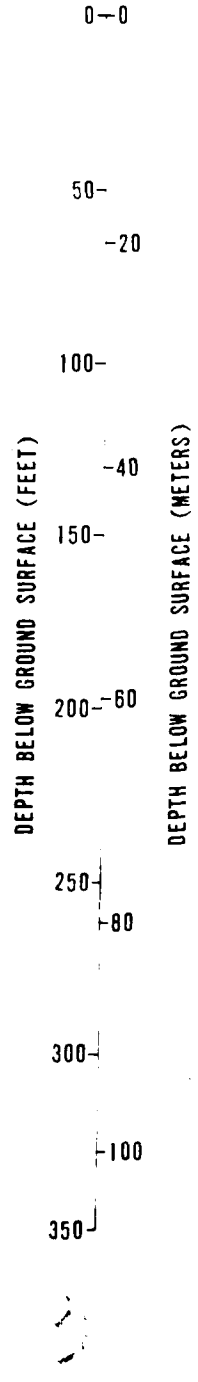
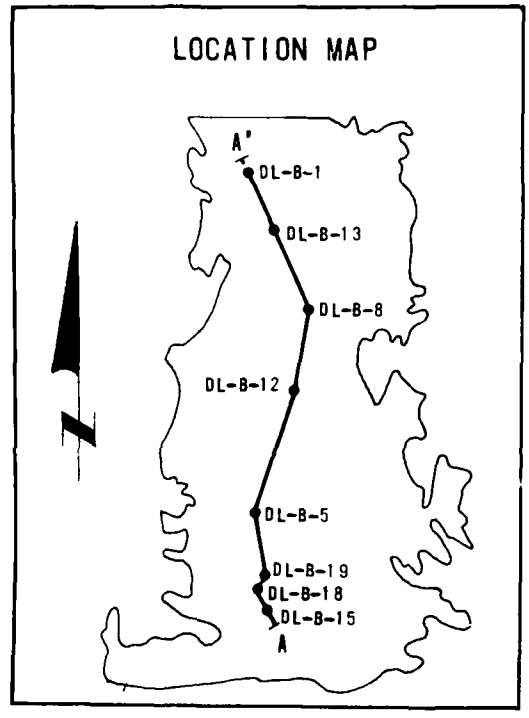

A
DL-B-15
ELEV. 4632'
(1412m)
DL-B-18
ELEV. 4602'
(1403m)
DL-B-19
ELEV. 4588'
(1398m)
DL-B-5
ELEV 4582'
(1397m)
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0
20
40
60
80
100
0
50
100
150
200
250
300
350
SW-SM
ML
SM
SP-SM
SP
SC
CH
MH
T.D. 300.3'
(91.5m)
T.D. 451.9'
(137.7m)
T.D. 300.4'
(91.6 m)
HORIZONTAL SC
STATUTE MILES 0 2
KILOMETERS 0 2 4



NOTES: 1. T.D.= Total Depth
2. Soil types shown adjacent to soil column are based on Unified Soil Classific (USCS) and are explained in the appendix







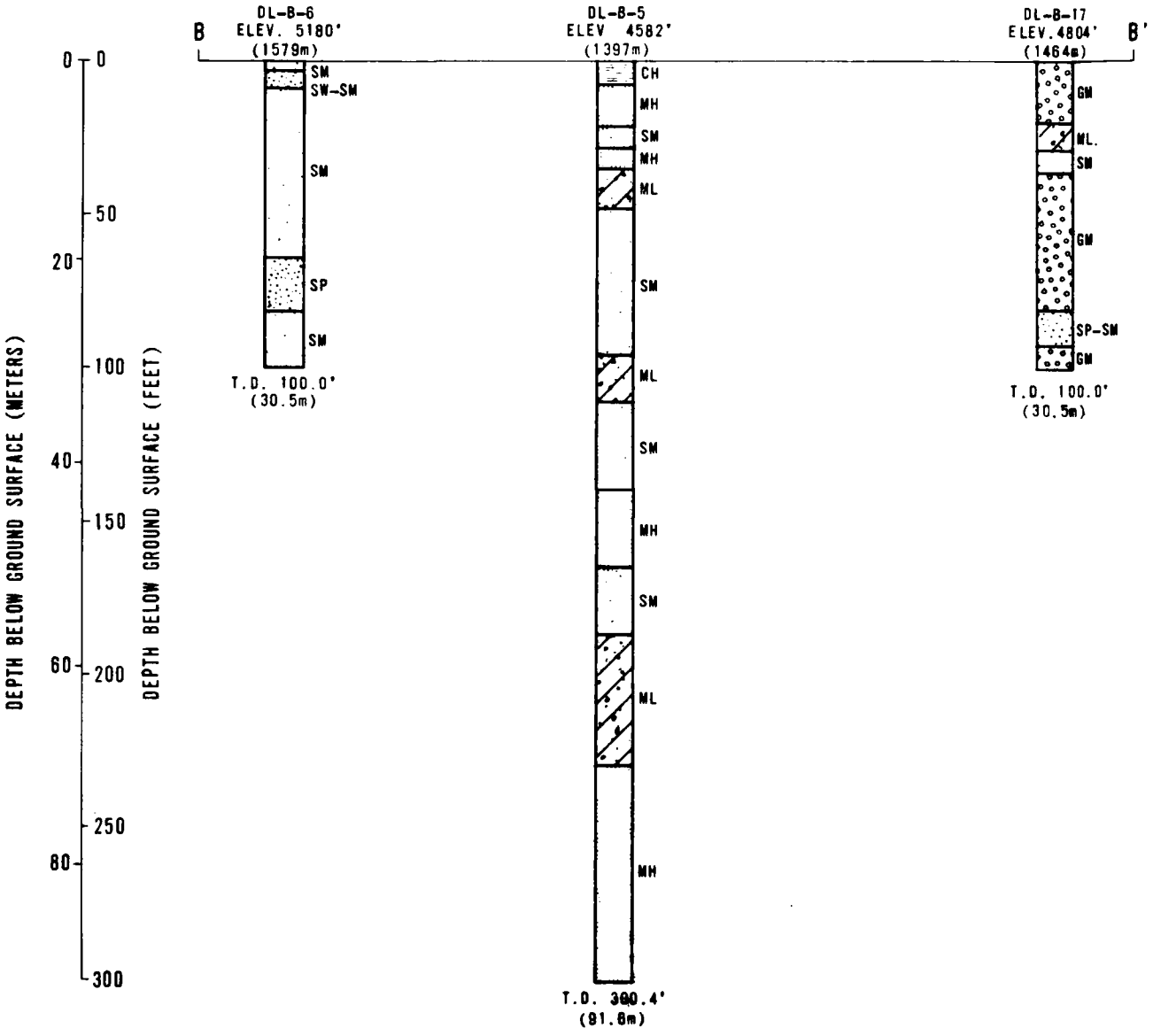
d Soil Classification System

SOIL PROFILE AA'
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 3

FUGRO NATIONAL, INC.

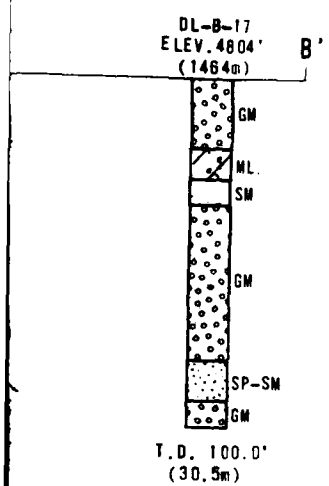


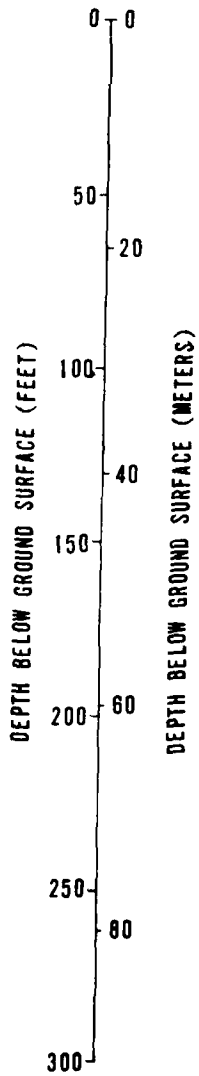
NOTES:
1. T.D. = Total Depth
2. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the appendix.

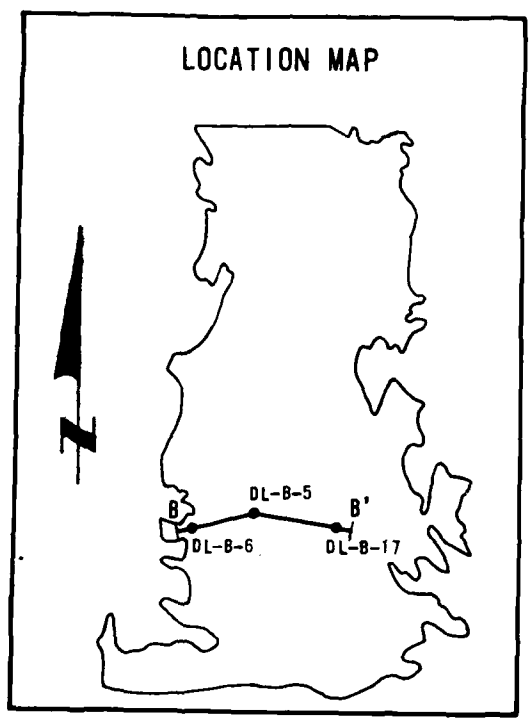
HORIZONTAL SCA

STATUTE MILES 0 2

KILOMETERS 0 2 4







HORIZONTAL SCALE

LES 0 2 4

ERS 0 2 4 6

SOIL PROFILE BB'
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 4

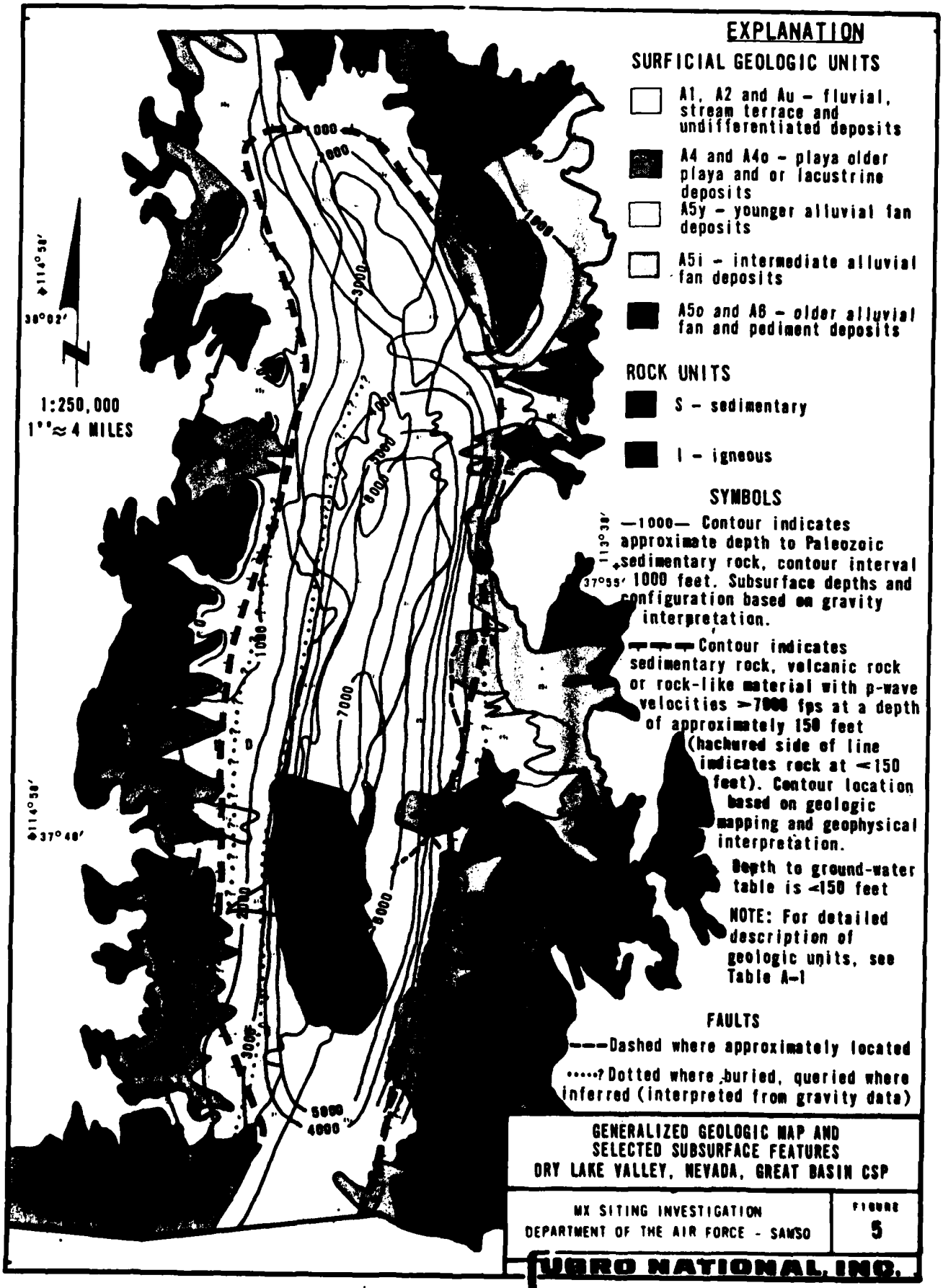
FUGRO NATIONAL, INC.

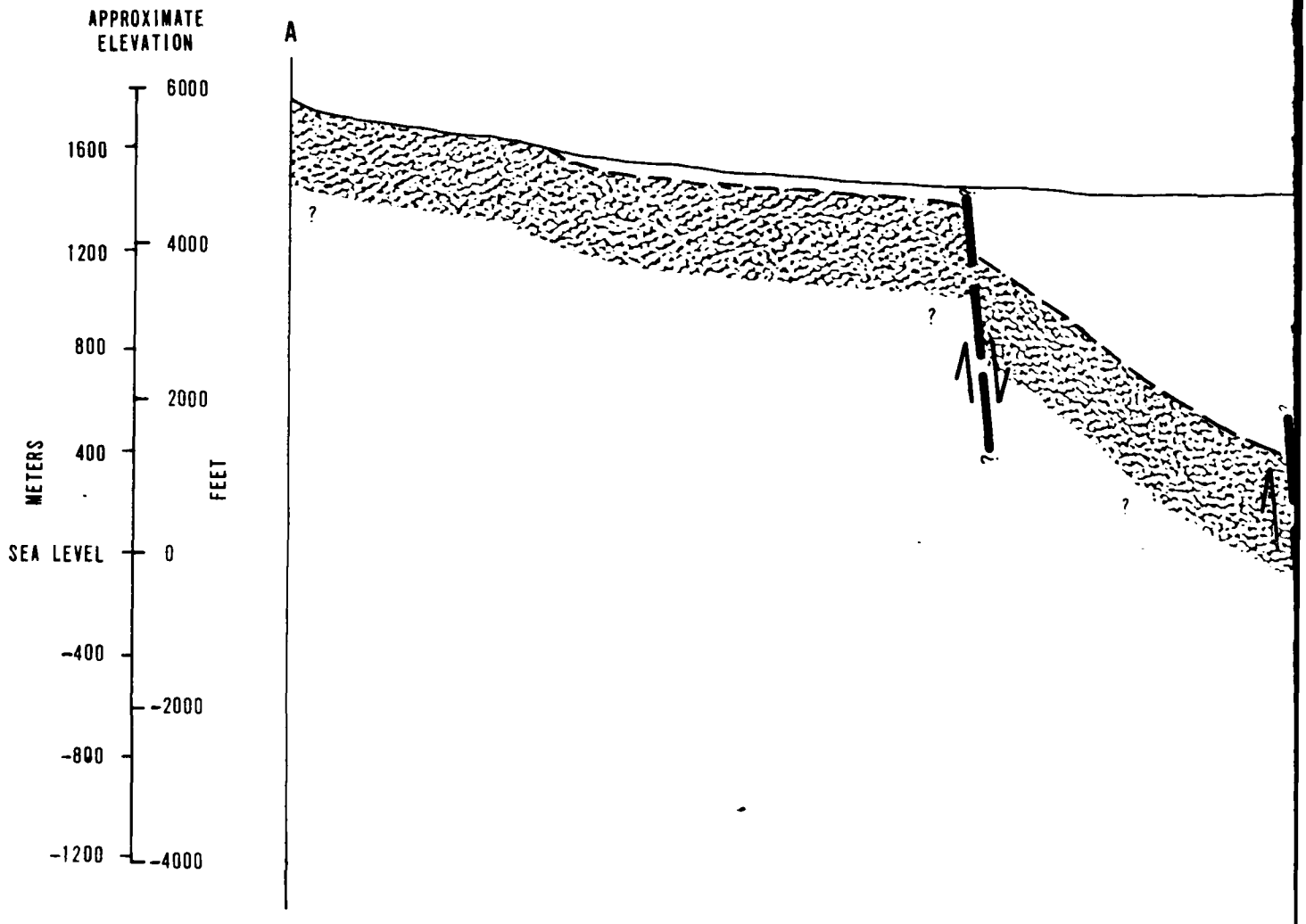
2.3.2 Depth to Shallow (<150 ft; <46 m) Rock and Water

Figure 5 shows the portions of the Dry Lake site in which rock (seismic velocity >7,000 fps; 2134 mps) and water are estimated to be encountered within a depth of 150 feet (46 m) below the ground surface. Shallow rock comprises approximately 20 percent of the site based on data and interpretation from borings, seismic surveys, gravity surveys, surface outcrops, topography, geologic maps, and other available data. Ground water is nowhere less than 150 feet (46 m) below the surface and probably greater than 300 feet (91 m) based on information from five wells and regional data.

2.3.3 Basin Configuration

Data from deep seismic refraction, gravity, and ground magnetic surveys were used in determining the basin configuration illustrated in Figures 5 and 6. Deep seismic data indicate a layered relationship of basin-fill deposits and/or younger volcanic rocks. Gravity survey data indicate the greatest depth to Paleozoic carbonate and clastic bedrock units to be approximately 6200 feet (1890 m) below the surface in the area of the generalized geologic cross-section (Figures 5 and 6). The basin is bounded on the east, west, and north by steep gradients in basement topography typical of those associated with normal faults. A fault scarp exposed along the east side of the valley coincides with an inferred basement fault, with displacement down on the basinward side. Planated rock shelves, covered by approximately 150 feet (46 m) of basin-fill deposits are inferred along the eastern and western valley margins. The distal limits of these rock


EXPLANATION
SURFICIAL GEOLOGIC UNITS
A1, A2 and Au – fluvial, stream terrace and undifferentiated deposits
A4 and A4o – playa older playa and or lacustrine deposits
A5y – younger alluvial fan deposits
A5i – intermediate alluvial fan deposits
A5o and A6 – older alluvial fan and pediment deposits
ROCK UNITS
S – sedimentary
I – igneous
SYMBOLS
—1000— Contour indicates approximate depth to Paleozoic sedimentary rock, contour interval 1000 feet. Subsurface depths and configuration based on gravity interpretation.
Contour indicates sedimentary rock, volcanic rock or rock-like material with p-wave velocities >7000 fps at a depth of approximately 150 feet (hachured side of line indicates rock at <150 feet). Contour location based on geologic mapping and geophysical interpretation.
Depth to ground-water table is <150 feet
NOTE: For detailed description of geologic units, see Table A-1
FAULTS
Dashed where approximately located
Dotted where buried, queried where inferred (interpreted from gravity data)
1:250,000
1" ≈ 4 MILES
114°58'
38°02'
37°48'
113°38'
37°55'
1000
2000
3000
4000
5000
6000
7000
8000
GENERALIZED GEOLOGIC MAP AND SELECTED SUBSURFACE FEATURES
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO
FIGURE 5
WOODWARD-CLYDE CONSULTANTS



EXPLANATION

Playa (A4) and older lacustrine and or playa (A4o) deposits — — —?—

Undifferentiated basin-fill deposits
Predominantly alluvial (A5) deposits, with fluvial (A1), stream terrace (A2s) and other non-rock deposits (Au)

Undifferentiated volcanic and sedimentary rock

NOTES: 1. The cro
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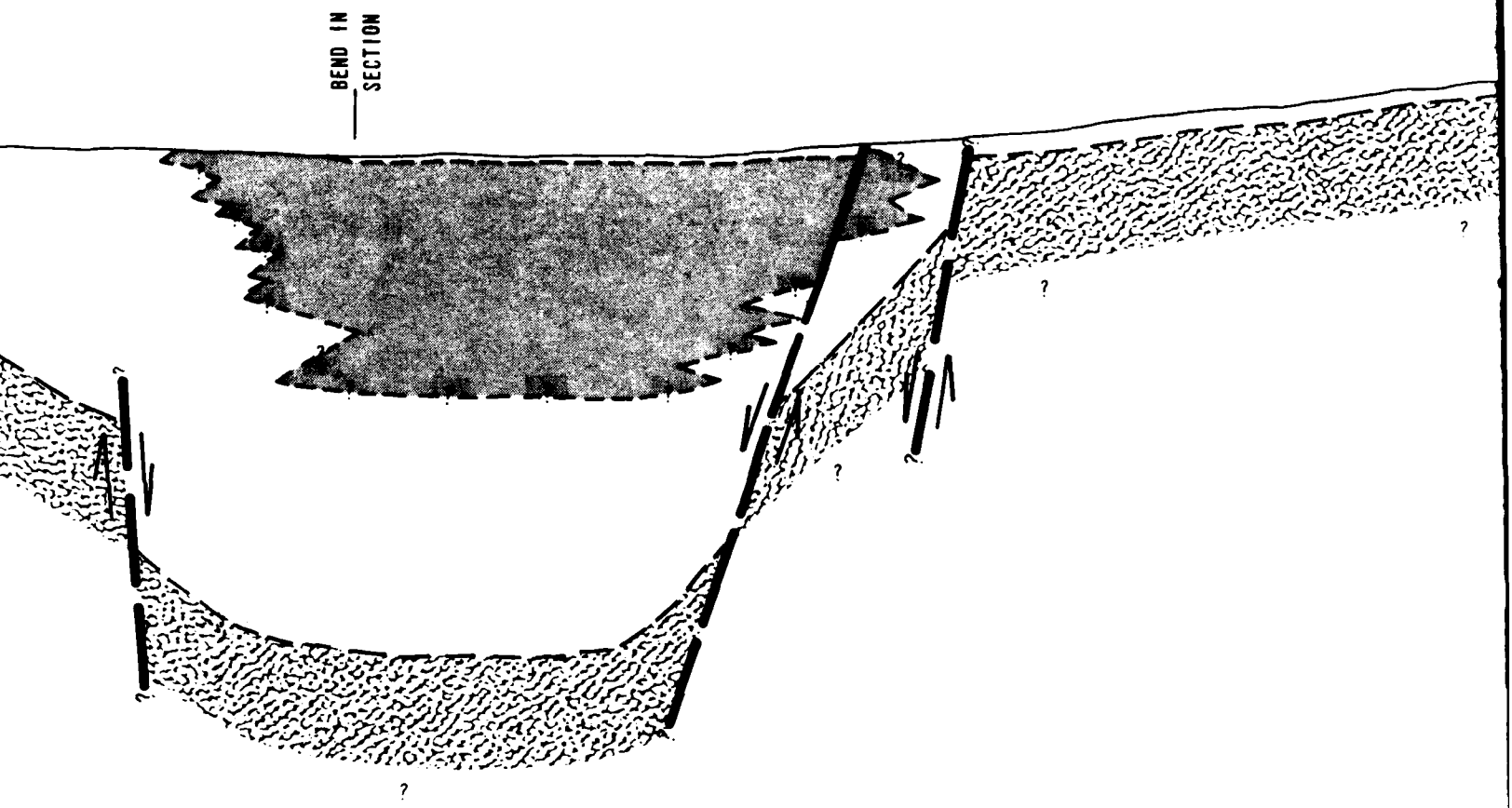
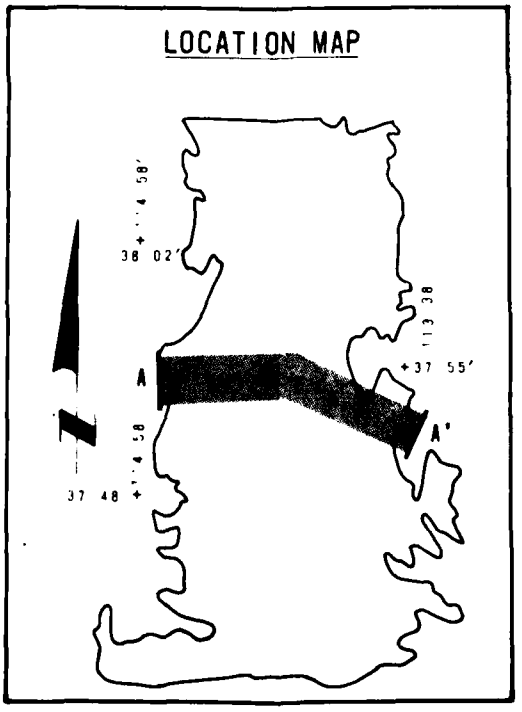
2. For a d



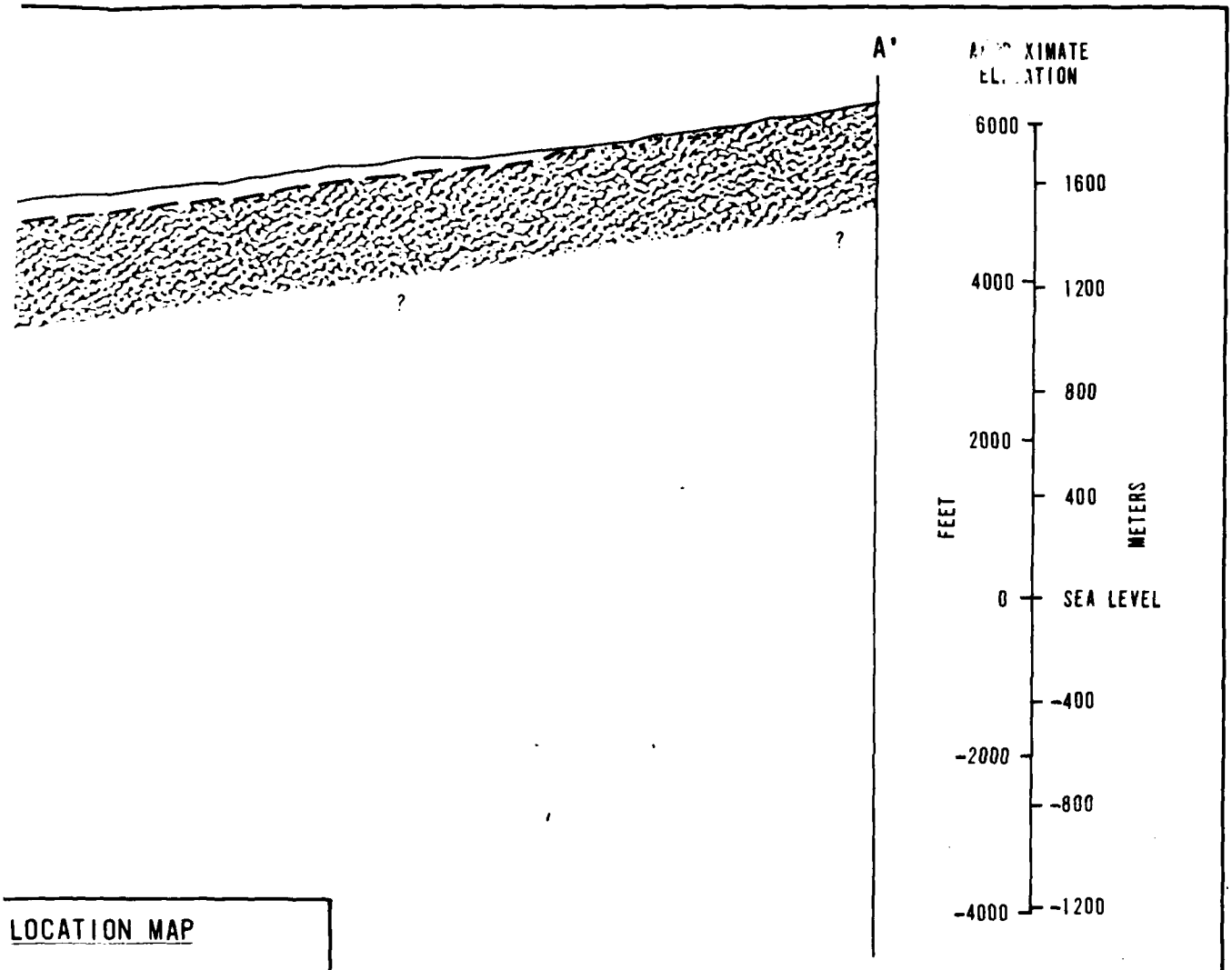


— —?— Approximate geologic contact queried where inferred

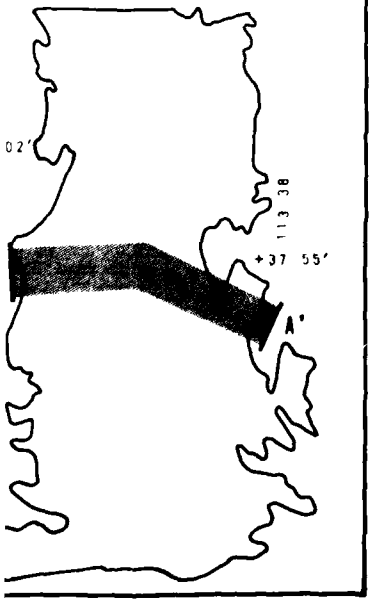
▬ ▬ Fault, dashed where inferred from gravity interpretation

1. The cross section is generally representative of subsurface conditions within the band shown on the location map. Due to the limited density of available data and the sparseness of newly acquired data, the subsurface conditions are highly interpretive.
2. For a detailed description of geologic units see Table A-1.

2.



LOCATION MAP



Horizontal Scale: 1"≈ 1 Mile (1.6 km)
Vertical Scale: 1"= 2000' (610 m)
Vertical Exaggeration: 2.6X

HORIZONTAL SCALE

STATUTE MILES 0 1 2

KILOMETERS 0 1 2 3

GENERALIZED GEOLOGIC CROSS SECTION
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 6

3

UGRO NATIONAL, INC.

shelves are located near the surface projection of the basement faults. Rock exposures and shallow (<150 ft; 46 m) rock do not occur basinward of these faults.

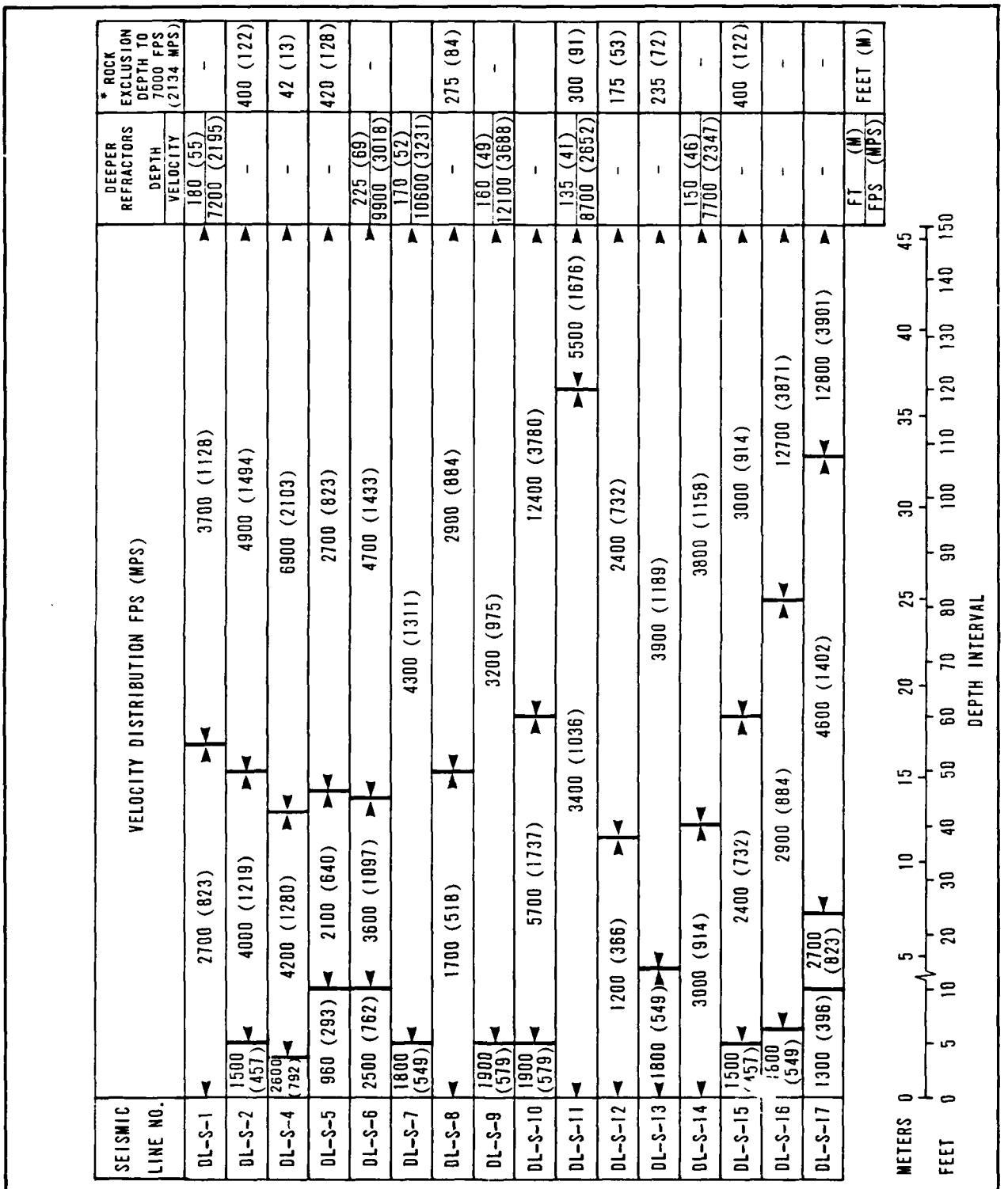
2.4 GEOPHYSICAL PROPERTIES

Results of shallow and deep seismic refraction surveys and downhole velocity surveys are presented in Tables 5, 6, and 7, respectively. Shallow seismic refraction results (Table 5) indicate dipping and laterally discontinuous velocity horizons. Deep seismic refraction results (Table 6) indicate discontinuous velocity horizons probably due to an interfingering of basin-fill deposits with younger volcanic rocks or other basin-fill deposits. The compressional wave velocities from downhole velocity surveys (Table 7) do not correspond with those from shallow seismic refraction (Table 5) due to the anisotropy of the ground and method of measurement.

2.5 ENGINEERING PROPERTIES

Engineering properties of the subsoils representing the various geologic units were determined from laboratory tests. The tests included the following; classification, consolidation, shear strength, compaction, CBR, and chemical. The range of engineering properties and compressional wave velocities of the predominant geologic units is presented in Table 8.

Younger and intermediate alluvial fan deposits are combined into one unit since they could not be differentiated at depth. In addition, these two units have similar grain-size and engineering properties. Alluvial fan deposits consist predominantly of



* If no refracting interface or layer with a velocity greater than 7000 fps (rock/rock-like material) was detected, a rock exclusion depth calculation was performed to determine the minimum depth at which rock could occur.

SHALLOW SEISMIC REFRACTION RESULTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 5

UGRO NATIONAL, INC.

VELOCITY LAYER	COMPRESSIONAL WAVE VELOCITY FPS (MPS)	AVERAGE THICKNESS FT (M)	COMMENTS
1	2600 (792)	90 (27)	PINCHES OUT
2	3300-3900 (1006-1189)	150 (46)	-
3	6000-8200 (1829-2499)	500 (152)	DISCONTINUOUS
4	8200-9000 (2499-2743)	1200 (366)	DISCONTINUOUS
5	14,000-16,000 (4267-4877)	UNKNOWN	BASEMENT

LINE DL-DS-1

VELOCITY LAYER	COMPRESSIONAL WAVE VELOCITY FPS (MPS)	AVERAGE THICKNESS FT (M)	COMMENTS
1	2800 (853)	60 (18)	-
2	3900 (1189)	150 (46)	-
3	6600-7400 (2012-2256)	300 (91)	DISCONTINUOUS
4	9000-9300 (2743-2835)	700 (213)	-
5	14,000-16,000 (4267-4877)	UNKNOWN	BASEMENT

LINE DL-DS-2

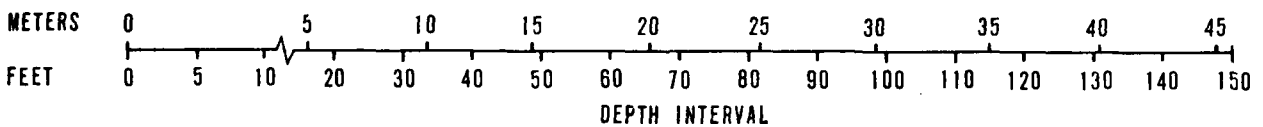
DEEP SEISMIC REFRACTION RESULTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 6

FUGRO NATIONAL, INC.

DOWNHOLE SURVEY NO.	VELOCITY DISTRIBUTION FPS (MPS)					WAVE TYPE
DL-DV-2	2400 (732)	2800 (853)	3760 (1146)			P WAVE
	1400 (427)	1980 (604)	2160 (658)			S WAVE
DL-DV-18	1400 (427)	2050 (625)				P WAVE
	540 (165)	980 (299)	1200 (366)	980 (299)		S WAVE



DOWNHOLE VELOCITY SURVEY RESULTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 7

FUGRO NATIONAL, INC.

ENGINEERING AND GEOPHYSICAL PROPERTIES	Intermediate and younger alluvial fan deposits (A5i and A5y)	Playa deposits (A4
UNIFIED SOIL CLASSIFICATION SYMBOL(S)	SM, SW, SP, SC, GP, GM, GW	CH, MH, ML, SM
GENERAL PROPERTIES		
DRY DENSITY pcf(kg m^3)	79-120 (1265-1922)	70-94 (1121-1506
MOISTURE CONTENT (%)	0.2-27.7	10-42
DEGREE OF SATURATION (%)	18-75	28-95
SPECIFIC GRAVITY	2.64-2.67	2.61±
DEGREE OF CEMENTATION	None to moderate	None to weak
COMPRESSIONAL WAVE VELOCITIES fps(mps)	1240-4870 (378-1484)	1000-4700 (305-143
ELECTRICAL CONDUCTIVITY (mhos m)	DNA	DNA
GRAIN SIZE DISTRIBUTION (%)		
BOULDERS >12 inches(30cm)	0-5	0
COBBLES 3 to 12 inches(8to 30cm)	0-12	0
GRAVEL	0-70	0
SAND	25-98	0-79
SILT AND CLAY	0-48	21-94
PLASTICITY DATA		
LIQUID LIMIT	21-23	27-108
PLASTICITY INDEX	NP-11	NP-60
COMPRESSIBILITY DATA		
COMPRESSION AT 4 ksf(192kN/m^2) (%)	1-5	1 0-2 6
SWELL OR COLLAPSE UPON SATURATION (%)	0.5-1.8 (Swell)	0.8-2.8(Swell)
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION ksf(kN m^2)	3.3-4.1 (158-196)	2 9-5 4 (139-259)
CD TRIAXIAL COMPRESSION	c=0-6 ksf (287 kN m^2), ϕ= 33°-40	c=0-4 ksf (192 kN m^2), ϕ
DIRECT SHEAR ksf(kN m^2)	3.7-8.2 (177-393)	DNA
COMPACTION AND CBR DATA		
MAXIMUM DRY DENSITY pcf(kg m^3)	124.0-128.5 (1986-2058)	110.8± (1775 ±)
OPTIMUM MOISTURE CONTENT (%)	8.5-10.0	16.5 ±
CBR AT 90% RELATIVE COMPACTION	14-40	3±

DNA=DATA NOT AVAILABLE (INSUFFICIENT DATA OR TESTS NOT PERFORMED)

GEOLOGIC UNITS	
ya deposits (A4)	
H, MH, ML, SM	
-94 (1121-1506)	
10-42	
28-95	
2.61±	
None to weak	
-4700 (305-1433)	
DNA	
0	
0	
0	
0-79	
21-94	
27-108	
NP-60	
0 2 6	
8-2.8(Swell)	
-5 4 (139-259)	
f (192 kN m^2), ϕ =20 -32	
DNA	
.8± (1775 ±)	
16.5 ±	
3±	

RANGE OF ENGINEERING AND GEOPHYSICAL PROPERTIES
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

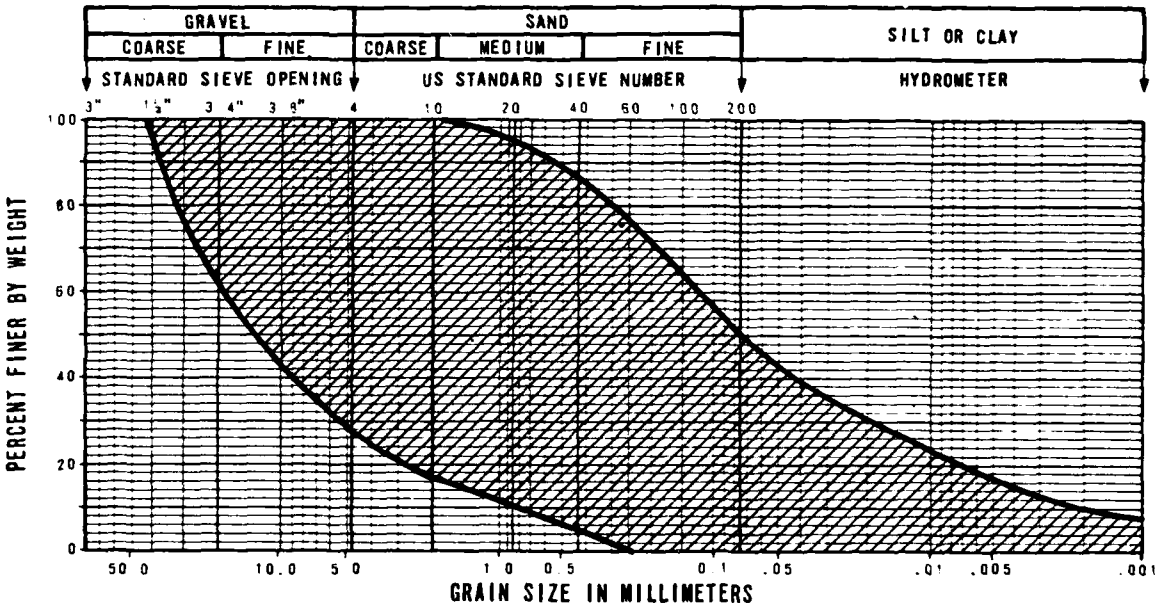
TABLE 8

FUGRO NATIONAL, INC.

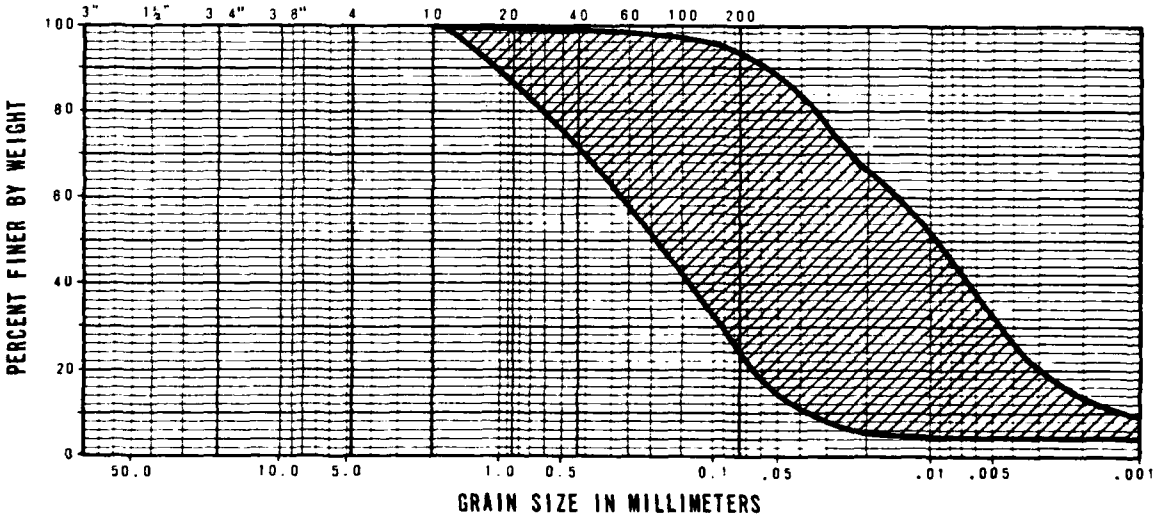
dense to very dense silty sands and sandy gravels, which are slightly compressible and have moderately high shear strengths. Playa deposits are composed primarily of stiff to very stiff silts and clays, which are moderately compressible and have moderate shear strengths.

The site soils generally are neither expansive nor collapsible. Range of gradation of the two geologic units is shown in Figure 7. Results of chemical tests on soils samples are presented in Table 9. The test results indicate that sulfate attack of soils on concrete will be "positive" in some areas of the site.

Representative logs of three borings and three trenches from the site are contained in Appendix B. Results of the shear strength and CBR tests performed on soil samples from the site and a summary of all the laboratory tests performed on soil samples obtained from boring DL-B-12 are also included in Appendix B.



A5



A4

RANGE OF GRADATION OF GEOLOGIC UNITS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 7

UGRO NATIONAL, INC.

BORING/ TRENCH NO	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	pH	WATER SOLUBLE				CALCIUM CARBONATE
		FEET	METERS			SODIUM	CHLORIDE	SULPHATE	CALCIUM	
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
DL-B-2	SS-4	20.0-21.2	6.10-6.46	SW-SM	6.7	53	10	39	34	85
DL-B-4	B-2	14.0-15.0	4.27-4.57	GM	7.1	30	33	29	93	233
DL-B-5	P-2	10.6-11.3	3.23-3.44	MH			1040	222	37	
	P-3	15.3-15.9	4.66-4.85	MH	7.7	6350	8150	1750	146	365
	P-6	30.0-30.7	9.14-9.36	MH	7.9	3210	4750	936	211	528
	P-11	80.6-81.3	24.57-24.78	SM	8.2	1500	1480	675	10	25
DL-T-8	B-3	8.0-9.5	2.44-2.90	SP	6.5	155	76	200	118	295
DL-B-12	P-2	10.0-10.7	3.05-3.26	ML	6.9	375	223	620	88	220
	P-30	294.7-295.3	89.82-90.01	ML	7.8	521	24	16	41	103
DL-T-12	B-2	3.0-5.0	0.91-1.52	SM	7.1	250	219	690	82	205
DL-B-19	B-1	0.0-1.6	0.0-0.49	CH	7.9	1000	836	450	36	90

SUMMARY OF CHEMICAL TEST RESULTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

TABLE 9

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FUGRO NATIONAL, INC.

FN-TR-28a

3.0 RALSTON VALLEY SITE

The Ralston Valley Characterization Site covers an area of 182 nm^2 (624 km^2) in western Nye County, Nevada. The site is bounded by mountain ranges on the east and west, Nellis Bombing and Gunnery Range on the south, and is open to the northern part of Ralston Valley on the north. U. S. Highway 6 and State Highway 8A provide paved highway access through the site while graded roads and four-wheel drive trails provide access within the site.

3.1 SCOPE OF INVESTIGATION

Scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site are presented in Table 10. Detailed information about the soils engineering field activities (15 borings and eight trenches) is summarized in Tables 11 and 12. Locations of all the field activities are shown in Figure 8.

3.2 SURFICIAL GEOLOGY AND TERRAIN

Alluvial fan deposits of younger and intermediate age are the predominant surficial geologic units within the Characterization site (Figure 8). The younger fan deposits cover approximately 23 percent of the area while the intermediate fan deposits cover 18 percent. Undifferentiated non-rock deposits, consisting of fluvial, alluvial, and playa and/or lacustrine deposits cover 24 percent of the area. These non-rock units were not differentiated due to the small scale (1:62,500) of mapping. Playa deposits cover approximately three percent of the surface.

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geological mapping stations	27
Shallow refraction	15
Deep refraction	2
Downhole velocity	3
Gravity survey	577
Ground magnetic stations	281

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
2	30 (9)
9	75-100 (23-30)
4	300 (91)

NUMBER OF TRENCHES	NOMINAL DEPTH FEET (METERS)
8	16 (5)

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	188
Specific gravity	15
Sieve analysis	144
Hydrometer	63
Atterberg limits	32
Consolidation	10

TYPE OF TEST	NUMBER OF TESTS
Unconfined compression	12
Triaxial Compression	21
Direct shear	16
Compaction	7
CBR	3
Chemical analysis	8

SCOPE OF FIELD AND LABORATORY ACTIVITIES
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 10

FUGRO NATIONAL, INC.

BORING NUMBER	TOTAL DEPTH FEET(METERS)	TYPE OF DRILL RIG USED	TYPE OF SAMPLES* OBTAINED
RV-B-1	300.0(91.4)	Rotary Wash	P,D,SS,B
RV-B-2	27.5(8.4)	Percussion	B
RV-B-3	30.0(9.1)	Percussion	B,SS
RV-B-4	87.0(26.5)	Percussion	B
RV-B-5	101.5(30.9)	Rotary Wash	P,SS,B
RV-B-6	300.5(91.6)	Rotary Wash	P,B
RV-B-7	100.2(30.5)	Rotary Air/Wash	P,D,SS,B
RV-B-8	300.7(91.7)	Rotary Wash	D,P
RV-B-9	100.7(30.7)	Rotary Wash	SS,P
RV-B-10	100.0(30.5)	Percussion	B,SS
RV-B-12	101.3(30.9)	Rotary Wash	P,D,B
RV-B-13	301.7(92.0)	Rotary Wash	D,SS,P
RV-B-14	75.0(22.9)	Percussion	B
RV-B-15	82.0(25.0)	Percussion	SS,B
RV-B-16	100.0(30.5)	Percussion	B,SS

* P = Pitcher sample (undisturbed)
D = Fugro Drive sample (relatively undisturbed)
B = Bulk sample (disturbed, but representative)
SS = Split Spoon sample (disturbed, but representative)

ENGINEERING FIELD ACTIVITIES - BORINGS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 11

FUGRO NATIONAL, INC.

TRENCH NUMBER	TOTAL DEPTH FEET (METERS)	STABILITY OF VERTICAL EXCAVATION WALLS
RV-T-6	18.0 (5.5)	stable
RV-T-7	18.0 (5.5)	unstable; trench caved in after heavy rain
RV-T-8	18.0 (5.5)	0-9' (0-2.7m) unstable; heavy sloughing into trench 9-18' (2.7-5.5m) stable
RV-T-9	18.0 (5.5)	0-2' (0-0.6m) unstable; some sloughing 2-18' (0.6-5.5m) stable
RV-T-10	18.0 (5.5)	stable
RV-T-13	18.0 (5.5)	0-6' (0-1.8m) unstable; some sloughing 6-18' (1.8-5.5m) stable
RV-T-14	18.0 (5.5)	0-8' (0-2.4m) unstable; sloughing into trench 8-18' (2.4-5.5m) stable; trench has numerous small caliche layers 3-14" (7.6-35.5cm) thick
RV-T-16	18.0 (5.5)	0-3' (0-0.9m) stable 3-10' (0.9-3.0m) unstable; sloughing into trench 10-18' (3.0-5.5m) stable

ENGINEERING FIELD ACTIVITIES - TRENCHES
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 12

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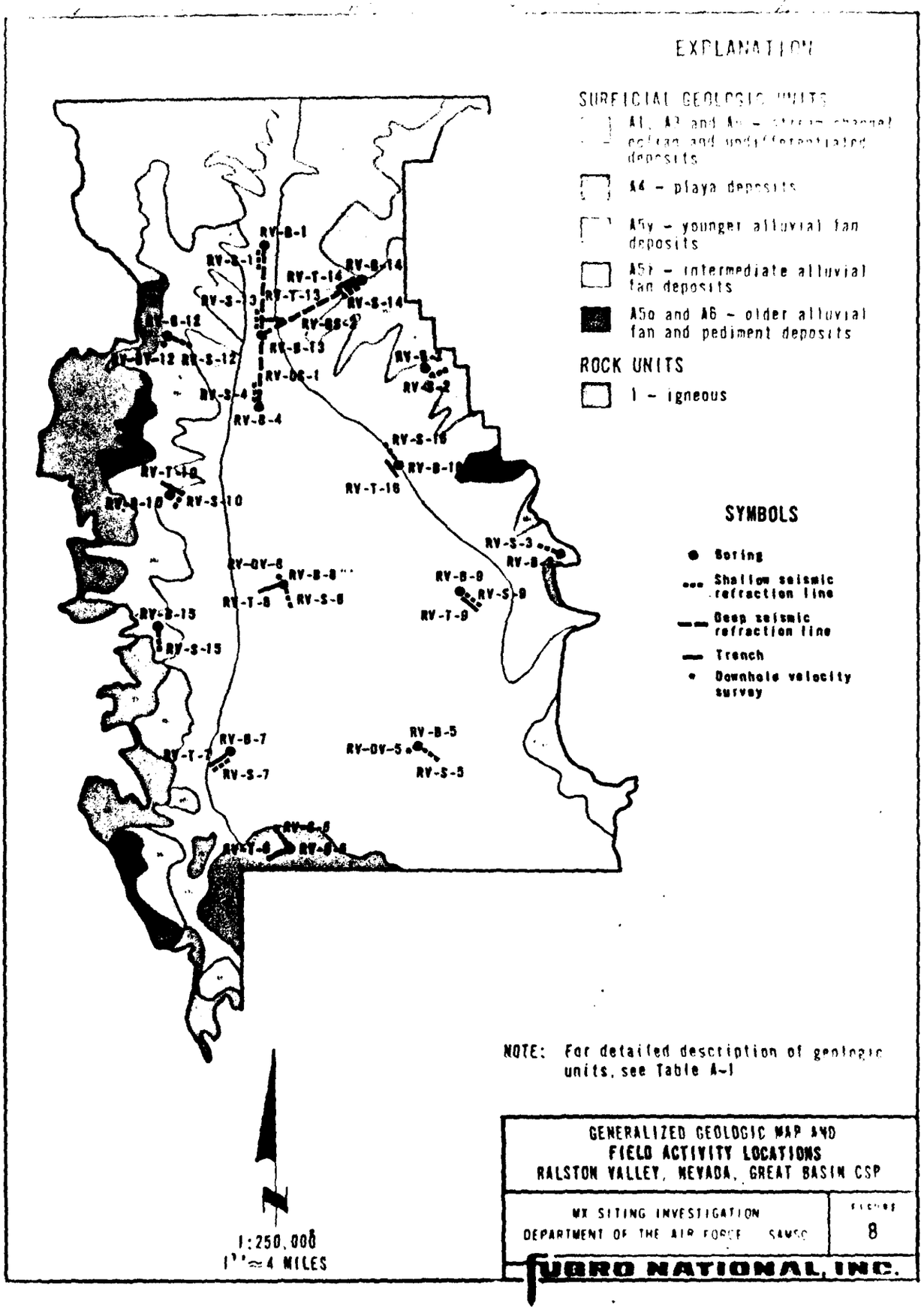

NOTE: For detailed description of geologic units, see Table A-1

GENERALIZED GEOLOGIC MAP AND
FIELD ACTIVITY LOCATIONS
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 8

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Twenty-one percent of the area consists of mixed playa and undifferentiated non-rock deposits. The large percentage (45%) of the area mapped as undifferentiated non-rock deposits or mixed playa and undifferentiated non-rock deposits is due to the broad, flat topography of the site. Playas located near the valley center and alluvial deposits located between the playa and the mountain front form an interfingering stratigraphic sequence.

Alluvial fan deposits are typically silty sands with gravel, ranging from sandy gravels near the mountain front to sandy silts near the playas. Playa deposits are generally silts. All the surficial geologic units are described in Table 13.

The maximum surface slope is ten percent but typical surface slope is only three percent. Depths of drainage incision (excluding older alluvial fan deposits) range from zero to 15 feet (0-5 m) with typical depths of five feet (1.5 m).

3.3 SUBSURFACE CONDITIONS

3.3.1 Soil Profiles

The soil profiles shown in Figures 9 and 10 illustrate the composition of soils with depth. Silty sands and gravelly sands are the dominant valley soils, and are interbedded with clayey silts near the valley center and sandy gravels near the mountain fronts. Cobbles and boulders are found near the mountain fronts. Cementation of the soils varies with soil type and age, generally increasing with age of soil. Sandy

SURFICIAL GEOLOGIC UNIT (a)	GEOLOGIC AGE	THICKNESS FEET (METERS)	DESCRIPTIVE NAME(S)	USCS SYMBOL(S) (b)	AREAL EXTENT (SITE)	
					nm^2 (km^2)	PERCENT
Undifferentiated Non-Rock Deposits (Au)	Quaternary-Tertiary	Unknown	Silty Sand with Gravel	SM	45 (154)	24
Alluvial Outwash Deposits (Alw)	Quaternary	Unknown	Silty Sand, Sand	SM, SP	7 (24)	4
Lake Terrace Deposits (A2l)	Quaternary-Tertiary	Unknown	Silty Sand with Gravel	SM	1 (3)	<1
Eolian Deposits, Undifferentiated (A3)	Quaternary	0-20 (0-6)	Sand with Gravel	SP	3 (10)	2
Playa Deposits (A4)	Holocene	Unknown	Silt with Sand and Clay	ML	44 (151)	24
Younger Alluvial Fan Deposits (A5y)	Holocene	Unknown	Silty Sand with Gravel	SM	41 (141)	23
Intermediate Alluvial Fan Deposits (A5i)	Pleistocene	Unknown	Gravelly Silty Sand, Sand	SM, SW, SP	36 (123)	20
Older Alluvial Fan Deposits (A5o)	Pleistocene	Unknown	Gravelly Silty Sand	SM	5 (17)	3

NOTES:

(a) For generic description of geologic units, see Table A-1.
(b) For description of USCS, see Table A-2.
(c) For description of stage of caliche, see Figure A-1.
(d) Mixed Al, A4, and A5 deposits.
(e) Consists of mixed Al, A5y and A5i deposits.
(f) Locally includes gravel, cobbles and boulders derived from upslope rock.
(g) Includes 21 percent mixed A4 and Au deposits; designated A4 Au on Figures 8 & 11.
(h) Includes two percent of area underlain by shallow rock, designated A6 on Figures 8 & 11

AREAL EXTENT (SITE)		PROPERTIES OF SURFACE MATERIALS					SURFACE MORPHOLOGY		NOTES
nm^2 (km^2)	PERCENT	GRADATION	CEMENTATION	MAXIMUM GRAIN SIZE	PAVEMENT/ PATINA	STAGE OF CALICHE (c)	SLOPE (PERCENT)	DRAINAGE DEPTHS FEET(METERS)	
45 (154)	24	Poor-Well	None-Moderate	Cobbles	None-Well/ None-Well	None-III	<1-10	0-25 (0-8)	(d)
7 (24)	4	Poor-Moderately well	Weak-Moderate	Boulders	None-Fair/ None-Fair	None-II	0-5	0-10 (0-3)	(e)
1 (3)	<1	Moderately well	Weak	Gravel	None-Fair/ None-Fair	None-I	1-5	0-2 (0-0.6)	
3 (10)	2	Poor	None-Weak	Cobbles	None/ None	None-I	0-10	0-5 (0-1.5)	(f)
44 (151)	24	Poor	None-Weak	Sand	None/ None	None-I	<1	0-2 (0-0.6)	(g)
41 (141)	23	Poor-Well	None-Weak	Cobbles	None-Poor/ None-Poor	None-I	0-5	0-3 (0-1)	
36 (123)	20	Poor-Well	Weak-Moderate	Boulders	Poor-Well/ None-Fair	II	1-10	2-15 (0.6-5)	(h)
5 (17)	3	Moderately well-Well	Moderate-Strong	Boulders	Poor-Well/ Poor-Well	III	5-10	5-25 (1.5-8)	

DESCRIPTION OF SURFICIAL GEOLOGIC UNITS
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 13

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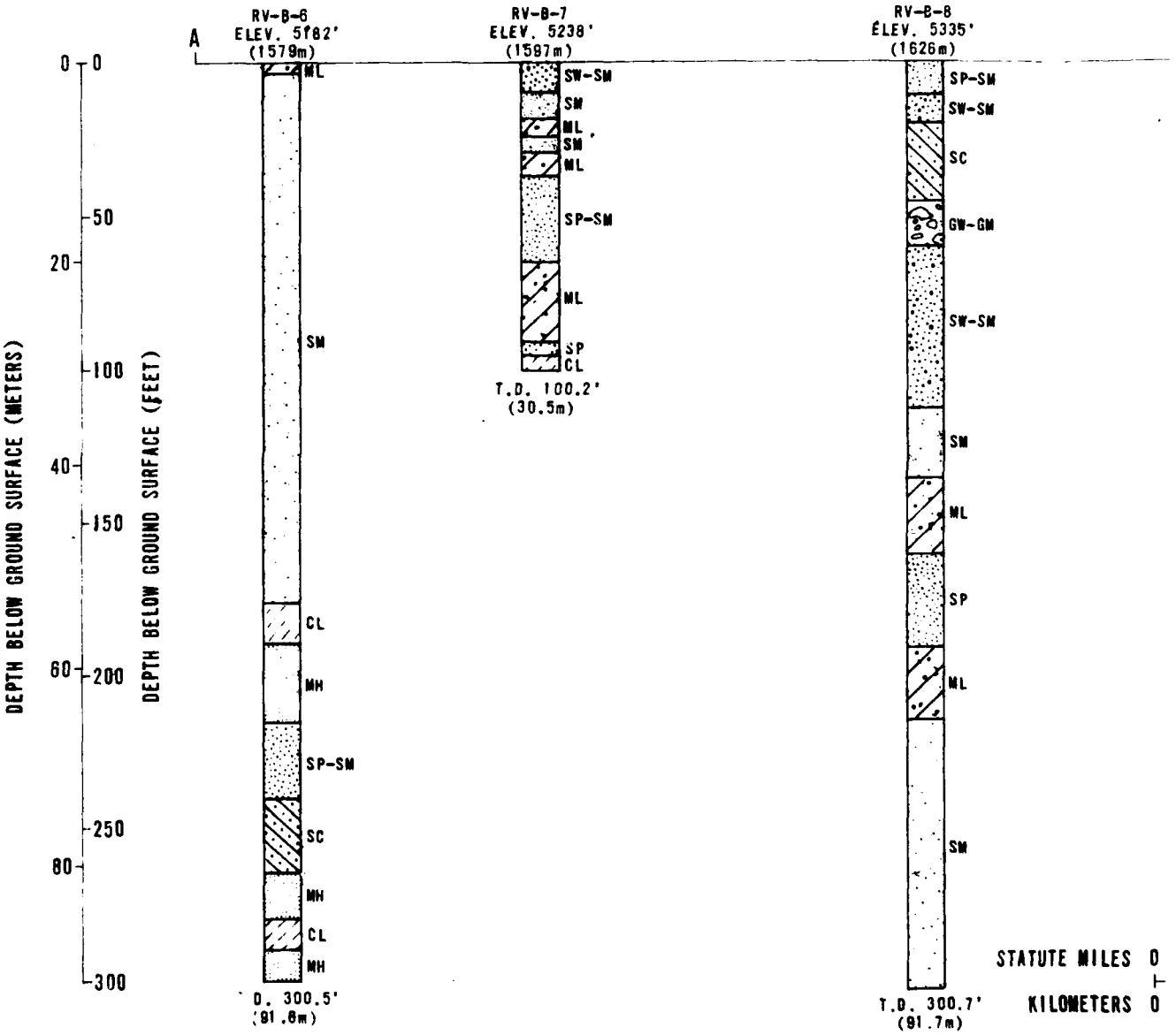
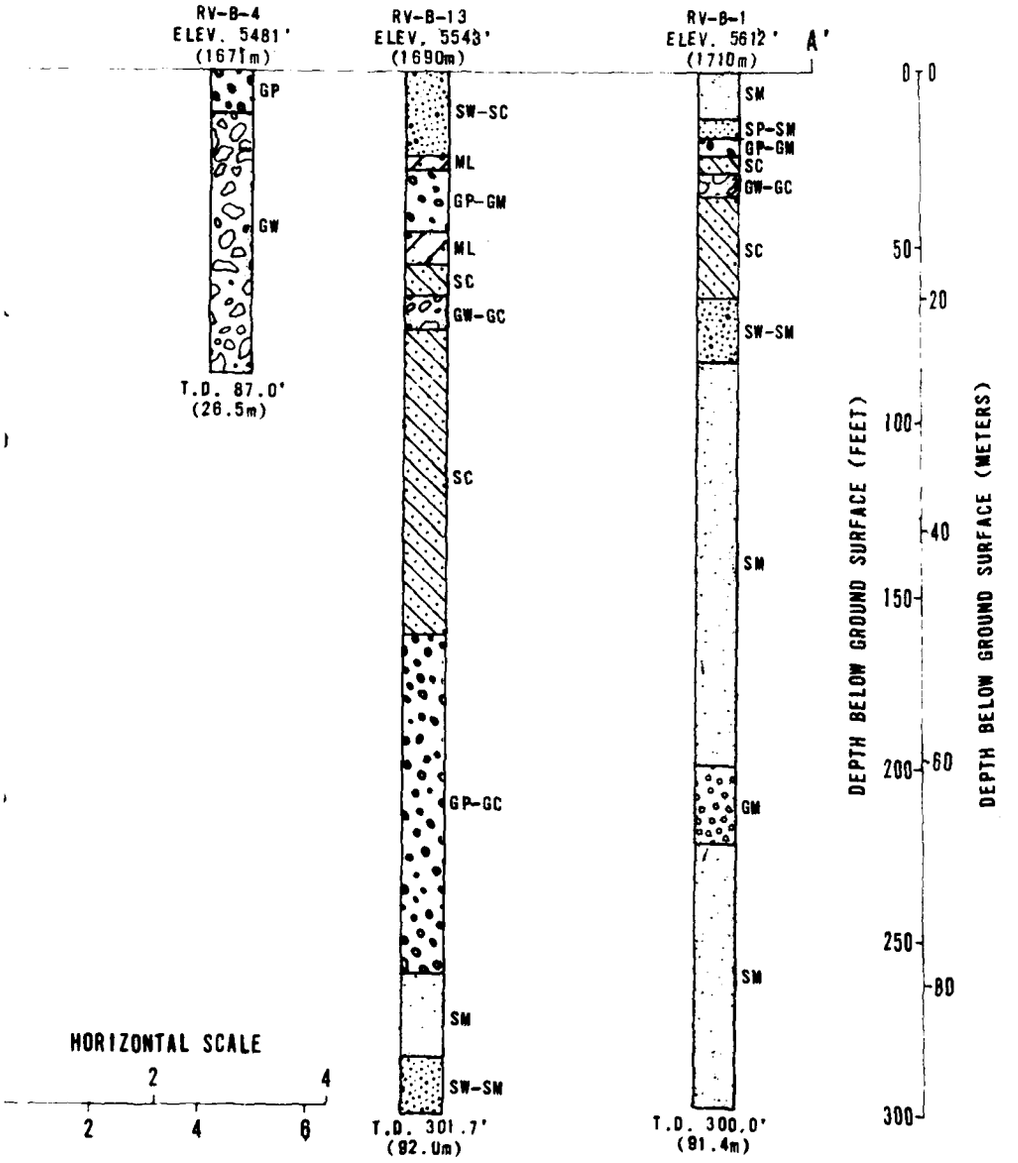
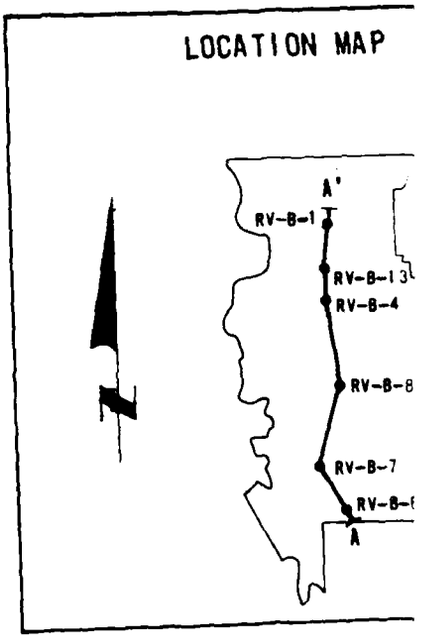


NOTES: 1. T.D.= Total Depth
2. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the appendix

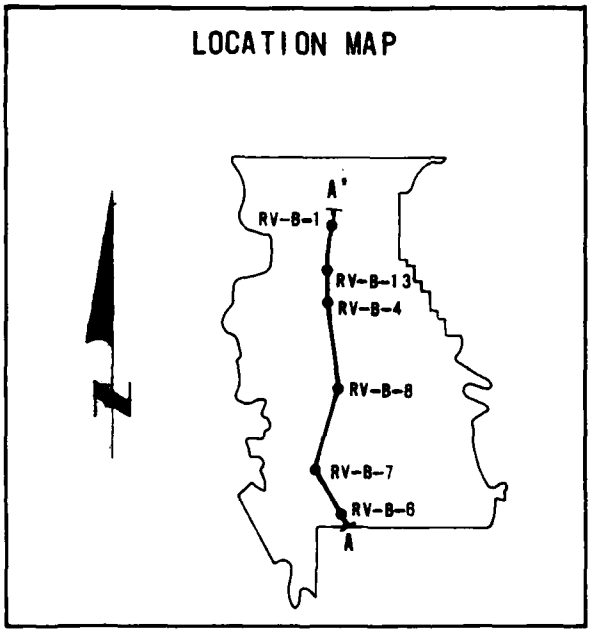


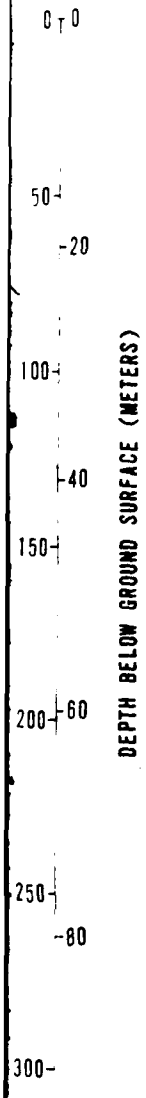


SOIL
RALSTON
GRE

MX SITING IN
DEPARTMENT OF THE

FUGRO N



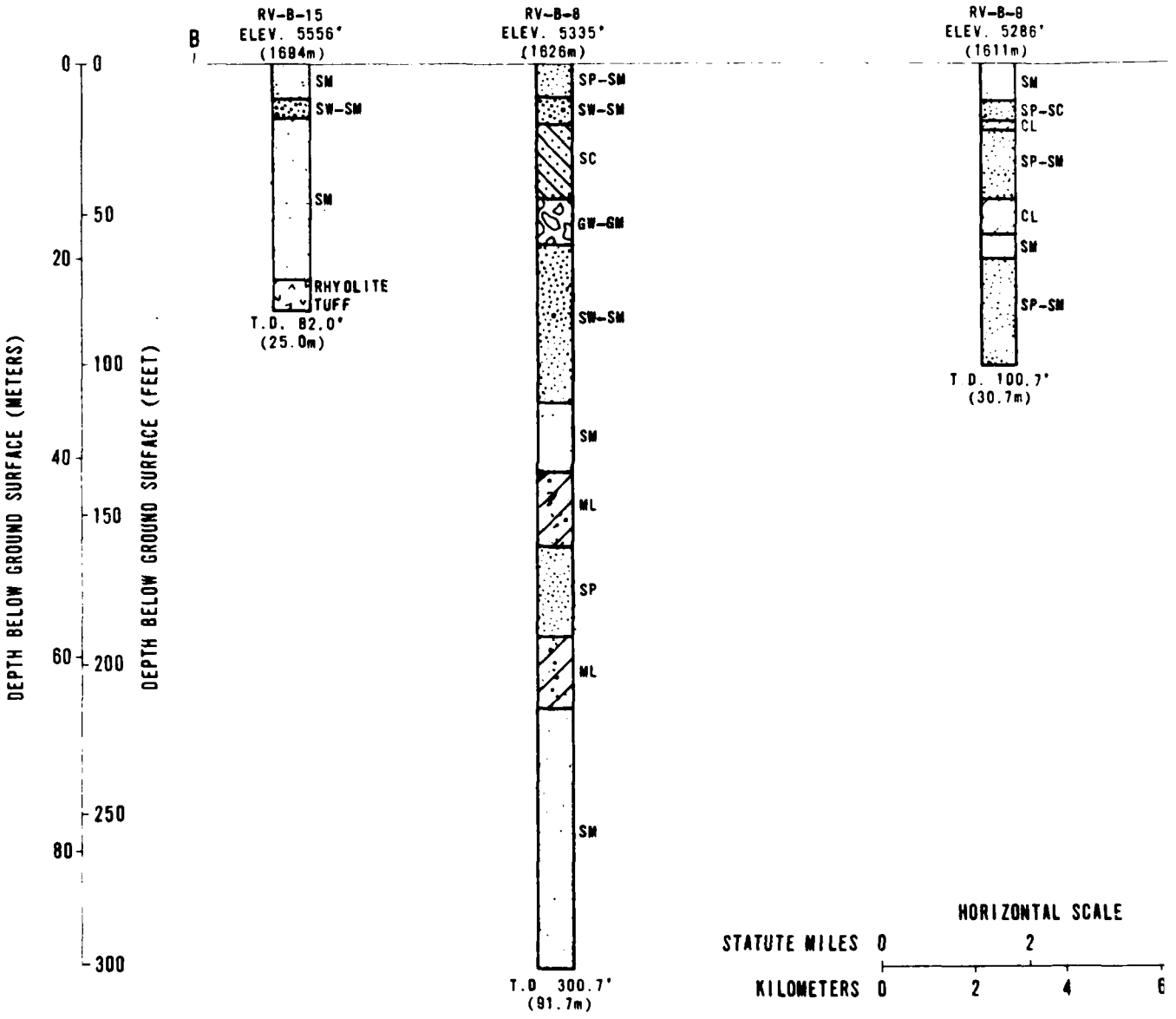


SOIL PROFILE AA'
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

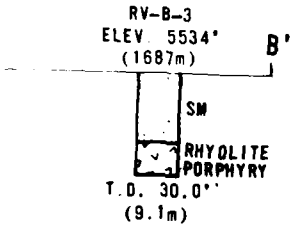
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

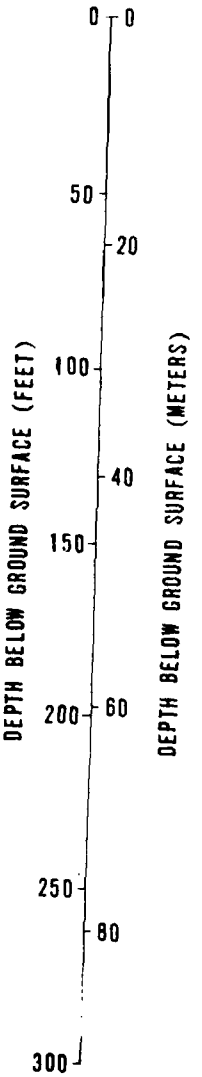
FIGURE 9

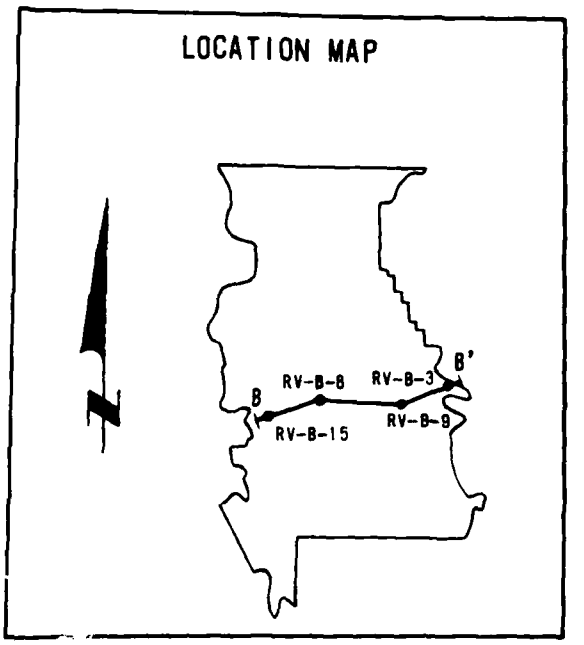
FUGRO NATIONAL, INC.



NOTES: 1. T.D.= Total Depth
2. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the appendix.







ALE

4

6

m

SOIL PROFILE BB'
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
10

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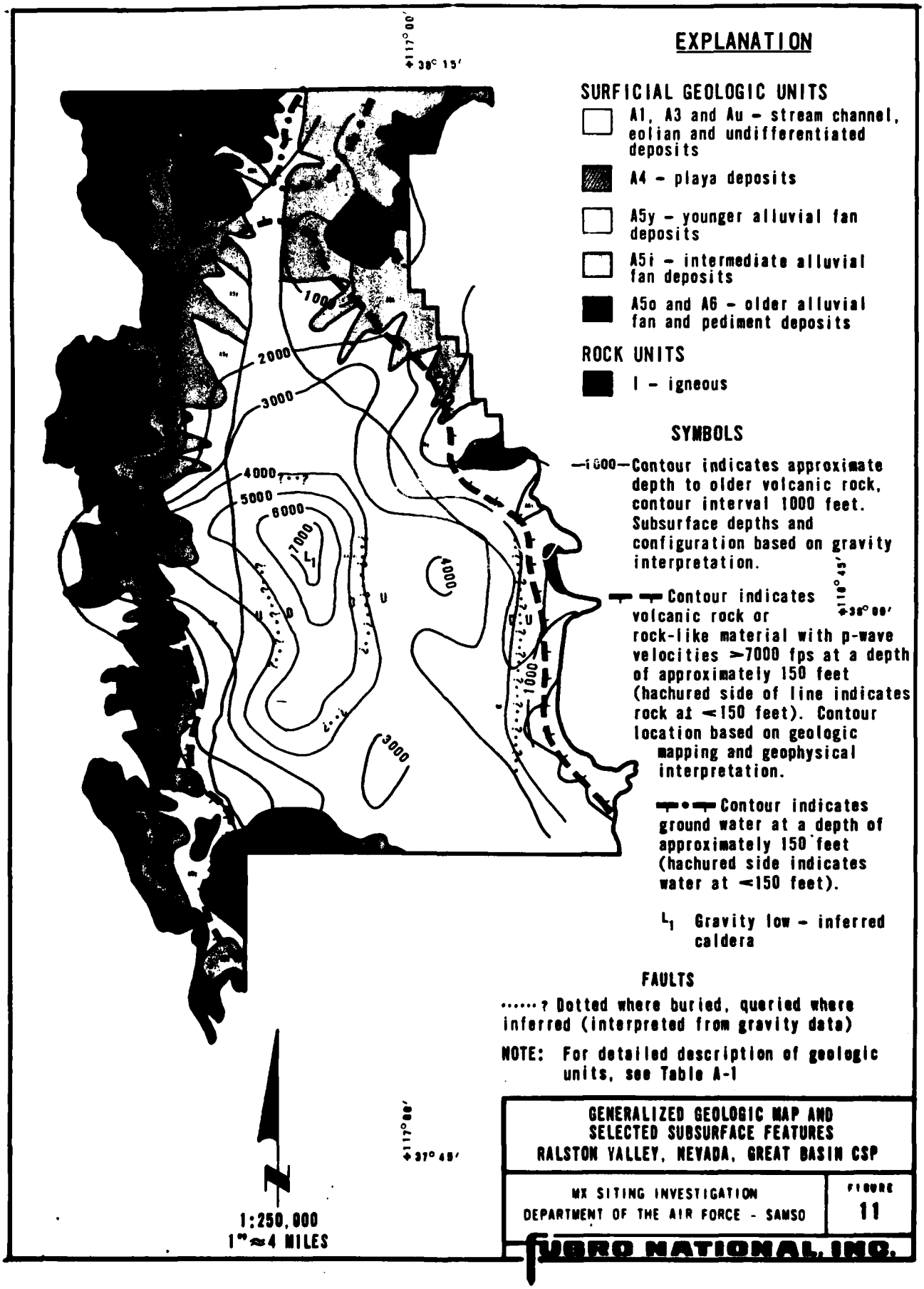
soils with less than five percent fines were generally uncemented to weakly cemented, often caving in unshored trenches.

3.3.2 Depth to Shallow (<150 ft; <46 m) Rock and Water

Figure 11 shows the portion of the Ralston Valley site in which rock (seismic velocity greater than 7000 fps; 2134 mps) and water are estimated to be within a depth 150 feet (46 m) below the ground surface. The portion of shallow rock area is approximately 15 percent of the site area. This analysis is based on data and interpretation from borings, seismic surveys, gravity surveys, surface outcrops, topography, and geologic maps. Depth to ground water is generally greater than 200 feet (61 m) below the surface except for an area near the northern site boundary (location of Tonopah well field used for domestic water supply) where ground-water levels range from 10 to 150 feet (3 to 46 m). The east-west ground-water barrier in this northern area does not show on the gravity contour map, and may represent interfingering of volcanic units and/or basin-fill deposits or an east-west trending intrusive body. Data in the Ralston site south of the Tonopah well field are from four wells and regional information.

3.3.3 Basin Configuration

The basin configuration was interpreted using deep seismic refraction, gravity and ground magnetic survey data. Deep seismic data indicate interbedding of the basin-fill deposits and/or volcanic rock units. The greatest depth to bedrock is approximately 7400 feet (2257 m) below the surface in



EXPLANATION

SURFICIAL GEOLOGIC UNITS

- A1, A3 and Au – stream channel, eolian and undifferentiated deposits
- A4 – playa deposits
- A5y – younger alluvial fan deposits
- A5i – intermediate alluvial fan deposits
- A5o and A6 – older alluvial fan and pediment deposits

ROCK UNITS

- I – igneous

SYMBOLS

—1000— Contour indicates approximate depth to older volcanic rock, contour interval 1000 feet. Subsurface depths and configuration based on gravity interpretation.

Contour indicates volcanic rock or rock-like material with p-wave velocities >7000 fps at a depth of approximately 150 feet (hachured side of line indicates rock at <150 feet). Contour location based on geologic mapping and geophysical interpretation.

Contour indicates ground water at a depth of approximately 150 feet (hachured side indicates water at <150 feet).

L_1 Gravity low – inferred caldera

FAULTS

..... ? Dotted where buried, queried where inferred (interpreted from gravity data)

NOTE: For detailed description of geologic units, see Table A-1

GENERALIZED GEOLOGIC MAP AND SELECTED SUBSURFACE FEATURES RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 11

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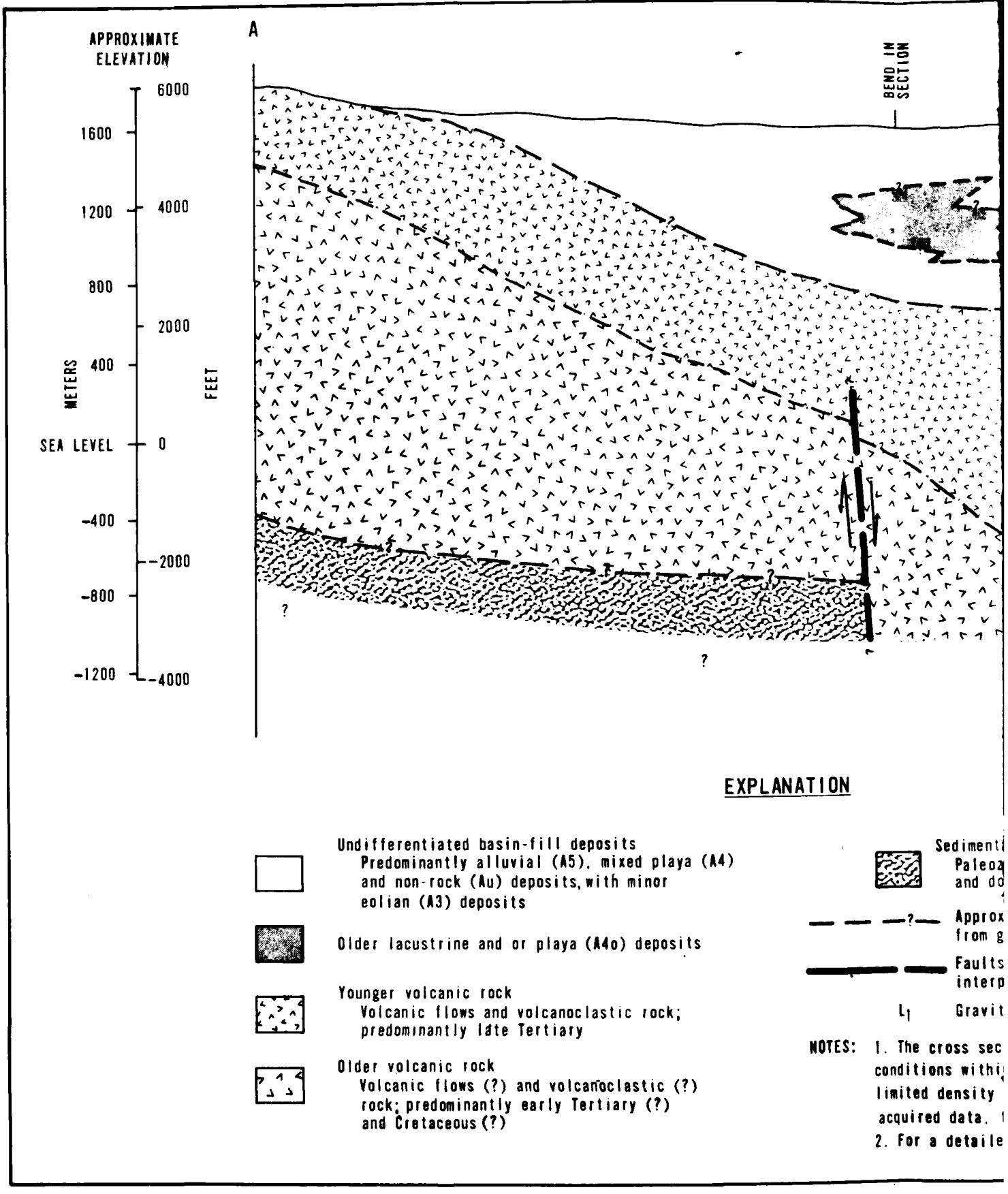
the area of L1 (Figure 11) along the generalized geologic cross-section (Figure 12). Cretaceous and early Tertiary volcanic rocks are the predominant bedrock unit defined in the gravity contour map. The basin is bounded on the east by steep gradients in basement topography typical of those associated with normal faults. No basement rocks are present at the surface west of this fault and a pediment is inferred east of the fault. The basin center is interpreted as a collapsed caldera overlain by younger volcanic rocks and basin-fill deposits (Figure 12). The subsurface basin configuration is illustrated in Figures 11 and 12.

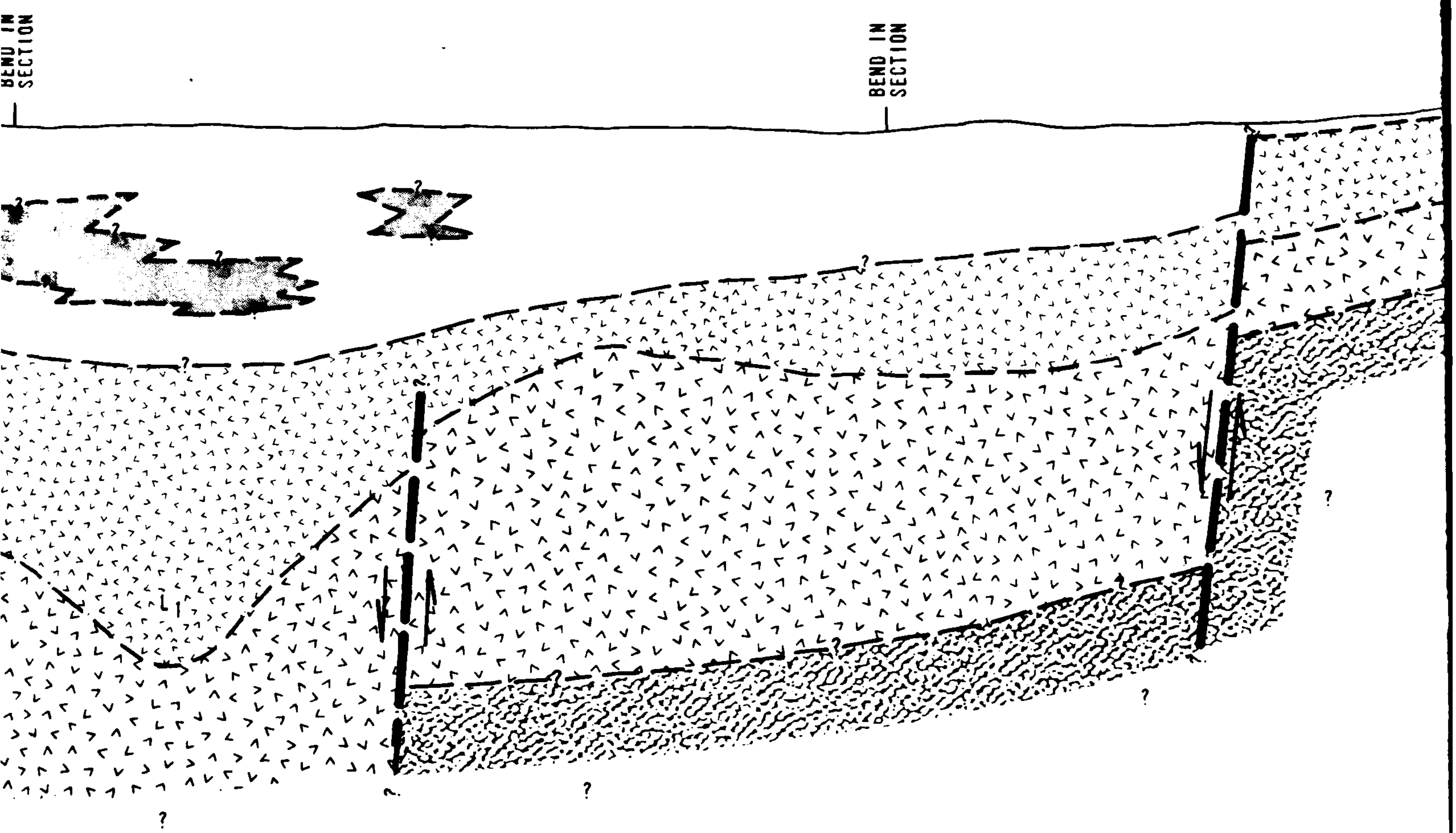
3.4 GEOPHYSICAL PROPERTIES

Results of shallow and deep seismic refraction surveys and downhole velocity surveys are presented in Tables 14, 15, and 16. Shallow seismic refraction results (Table 14) indicate a low velocity surficial layer overlying a zone of higher velocity horizons. Borings adjacent to the lines indicate that the change in velocity is probably due to increased consolidation of the soil and not due to a change in lithology. Deep seismic refraction results (Table 15) indicate the bedrock depth within the valley. The compressional wave velocities from downhole velocity surveys (Table 16) do not correspond with those from shallow seismic refraction (Table 14) due to the anisotropy of the ground and method of measurement.

3.5 ENGINEERING PROPERTIES

Laboratory tests were performed to determine the engineering properties of soil samples obtained from the various geologic


APPROXIMATE ELEVATION
METERS
FEET
6000
1600
4000
1200
800
2000
400
SEA LEVEL
0
-400
-2000
-800
-1200
-4000
A
BEND IN SECTION
?
?
EXPLANATION
Undifferentiated basin-fill deposits
Predominantly alluvial (A5), mixed playa (A4) and non-rock (Au) deposits, with minor eolian (A3) deposits
Older lacustrine and or playa (A4o) deposits
Younger volcanic rock
Volcanic flows and volcanoclastic rock; predominantly late Tertiary
Older volcanic rock
Volcanic flows (?) and volcanoclastic (?) rock; predominantly early Tertiary (?) and Cretaceous (?)
Sedimenta
Paleoz
and do
Approx
from g
Faults
interp
Gravit
NOTES: 1. The cross sec
conditions withi
limited density
acquired data.
2. For a detaile



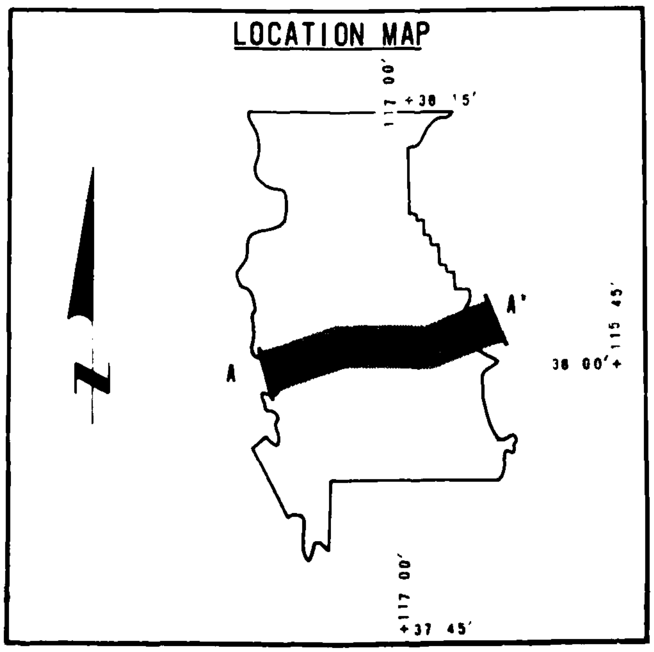
Sedimentary rock
Paleozoic rock, predominately limestone and dolomite with minor clastic beds

-?— Approximate geologic contact, queried where inferred from gravity interpretation

▬ Faults, dashed where inferred from gravity interpretation

L_1 Gravity low - inferred caldera

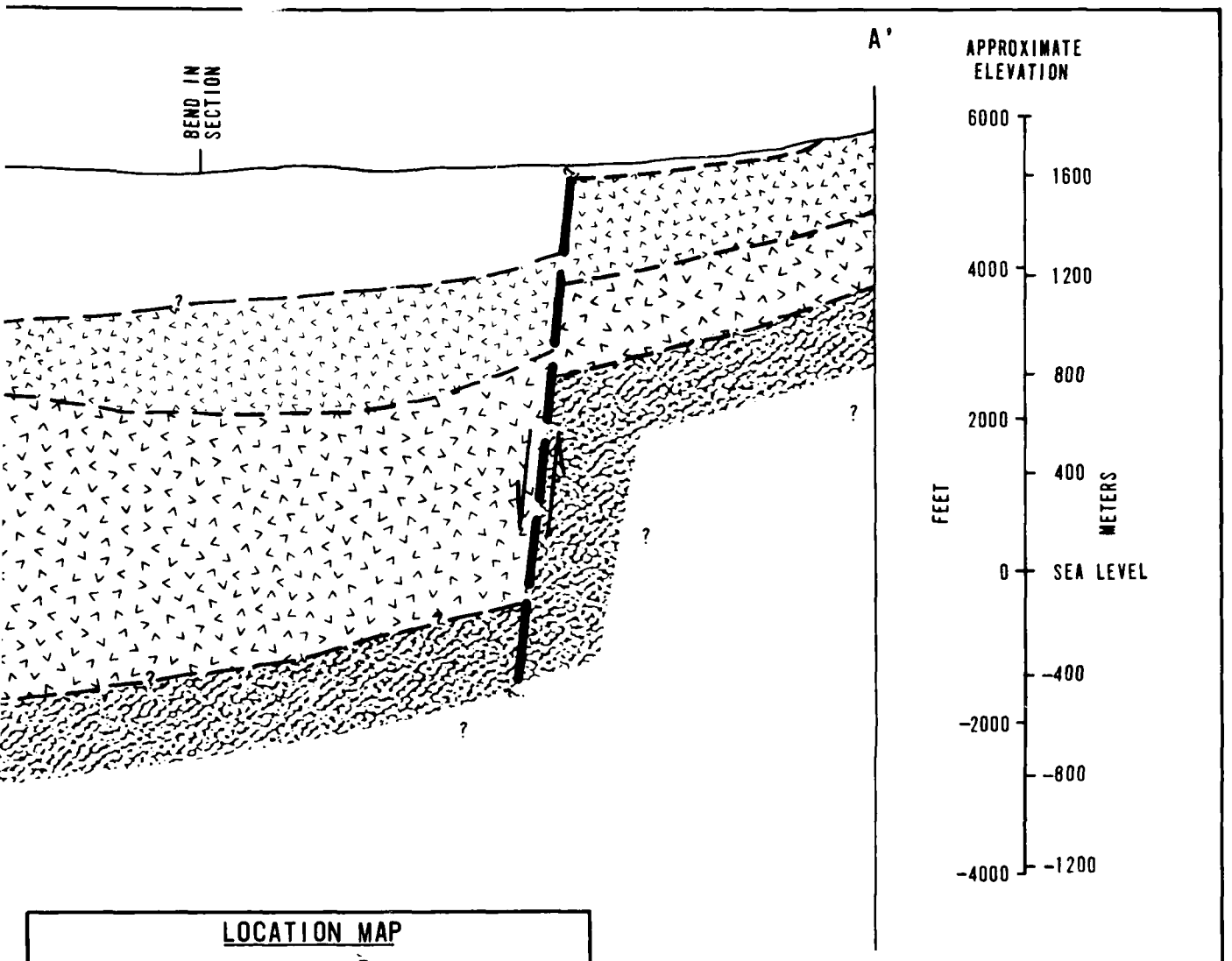
The cross section is generally representative of subsurface litions within the band shown on the location map. Due to the ited density of available data and the sparseness of newly uired data, the subsurface conditions are highly interpretive. or a detailed description of geologic units, see Table A-1.

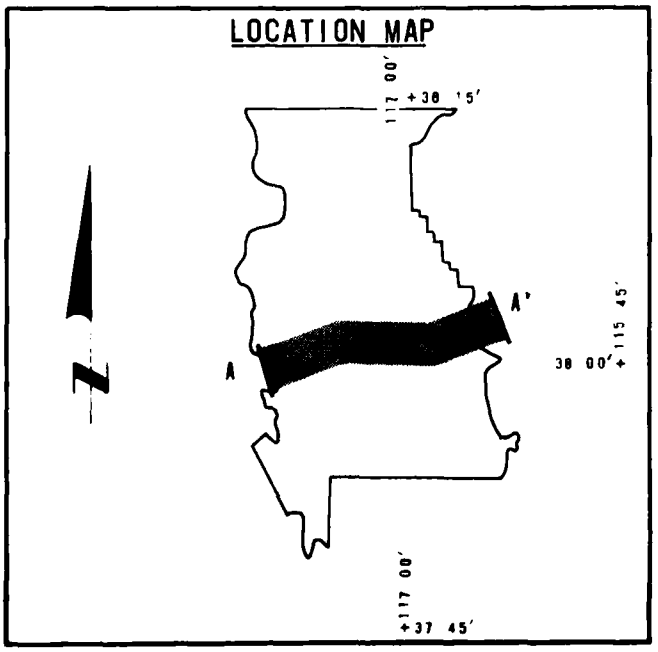


Horiz
Verti
Verti

STATUTE

KILOM





Horizontal Scale: 1" ≈ 1 Mile (1.6 km)
Vertical Scale: 1" = 2000' (610 m)
Vertical Exaggeration: 2.6X

HORIZONTAL SCALE

STATUTE MILES 0 1 2

KILOMETERS 0 1 2 3

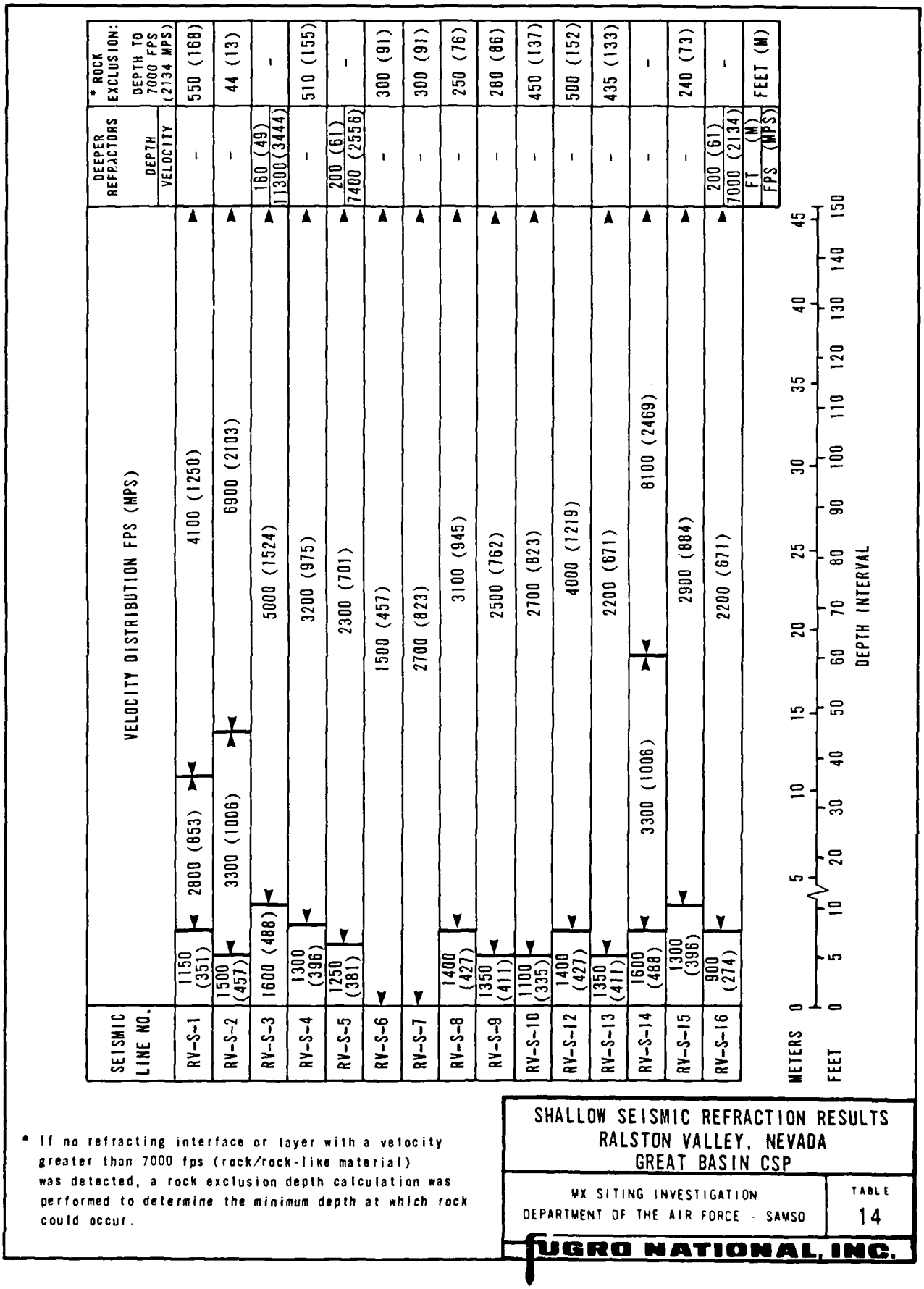
GENERALIZED GEOLOGIC CROSS SECTION
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 12

FUGRO NATIONAL, INC.

FN-TR-26e



* If no refracting interface or layer with a velocity greater than 7000 fps (rock/rock-like material) was detected, a rock exclusion depth calculation was performed to determine the minimum depth at which rock could occur.

SHALLOW SEISMIC REFRACTION RESULTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 14

UGRO NATIONAL, INC.

VELOCITY LAYER	COMPRESSIONAL WAVE VELOCITY FPS (MPS)	AVERAGE THICKNESS FT (M)	COMMENTS
1	2600-3100 (792-945)	100 (30)	-
2	4000-5200 (1219-1585)	300 (91)	-
3	7700-8500 (2347-2591)	400 (122)	-
4	10,500-11,300 (3200-3444)	1200 (366)	-
5	13,600 (4145)	2800 (853)	-
6	18,800 (5730)	UNKNOWN	BASEMENT

LINE RV-DS-1

VELOCITY LAYER	COMPRESSIONAL WAVE VELOCITY FPS (MPS)	AVERAGE THICKNESS FT (M)	COMMENTS
1	2500-3200 (762-975)	50 (15)	-
2	4500-5100 (1372-1554)	300 (91)	PINCHES OUT
3	7300 (2225)	200 (61)	PINCHES OUT
4	10,700 (3261)	500 (152)	-
5	13,600 (4145)	2300 (701)	-
6	18,800 (5730)	UNKNOWN	BASEMENT

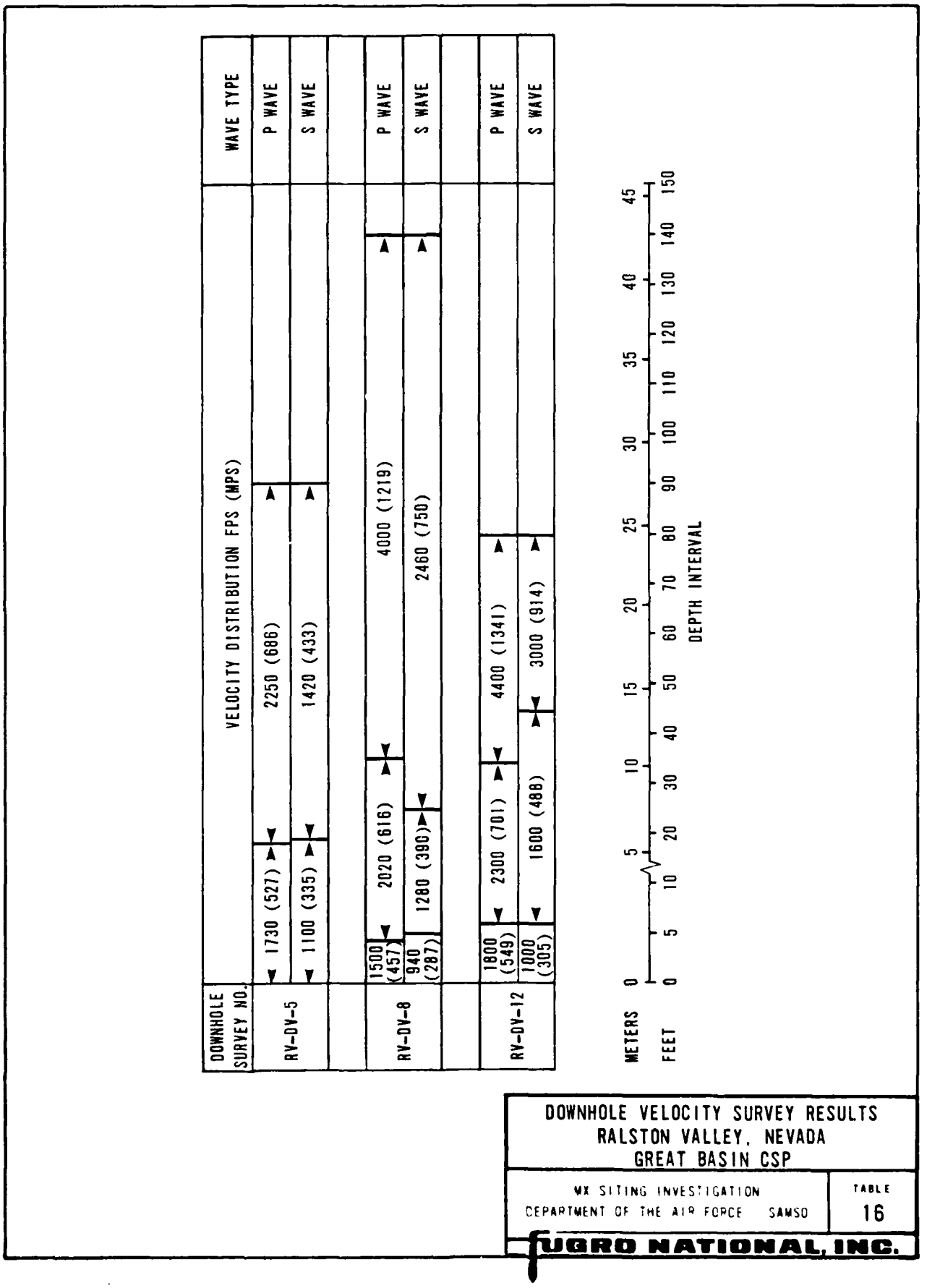
LINE RV-DS-2

DEEP SEISMIC REFRACTION RESULTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 15

UGRO NATIONAL, INC.



DOWNHOLE VELOCITY SURVEY RESULTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 16

UGRO NATIONAL, INC.

units. Laboratory analysis consisted of classification tests, consolidation tests, shear strength tests, compaction and CBR tests, and chemical tests. Table 17 presents the range of engineering properties and compressional wave velocities of predominant geologic units.

Younger and intermediate alluvial fan deposits are combined into one unit since they have similar grain-size and engineering properties, and could not be differentiated at depth. These deposits consist predominantly of dense to very dense silty sands and sandy gravels, which are slightly compressible and have moderately high shear strengths. Playa deposits are composed primarily of stiff to very stiff silts and clays, which are moderately compressible and have moderate shear strengths.

In general, the site soils are neither expansive nor collapsible. Figure 18 shows the range of gradation of the geologic units. Table 18 shows the results of chemical tests on soil samples, which indicate that sulfate attack of soils on concrete will be "positive" in some areas of the site.

Representative logs of three borings and three trenches from the site are contained in Appendix C. Shear strength and CBR test results, as well as a summary of all the laboratory tests performed on soil samples obtained from boring RV-B-6, are also included in Appendix C.

ENGINEERING AND GEOPHYSICAL PROPERTIES	Intermediate and younger alluvial fan deposits (A5i and A5y)	Playa deposits (A4
UNIFIED SOIL CLASSIFICATION SYMBOL(S)	SW. SP. SM. GP. GM	ML CL. MH. SP SM
GENERAL PROPERTIES		
DRY DENSITY pcf(kg m^3)	86-118 (1378-1890)	75-107 (1201-1714
MOISTURE CONTENT (%)	1-22	6-40
DEGREE OF SATURATION (%)	42-74	21-90
SPECIFIC GRAVITY	2 54-2 60	2.56-2 59
DEGREE OF CEMENTATION	Uncemented to moderate	Uncemented to weak
COMPRESSIONAL WAVE VELOCITIES fps(mps)	1000-6900 (305-2103)	1340-5700 (408-1737)
ELECTRICAL CONDUCTIVITY (mhos m)	DNA	DNA
GRAIN SIZE DISTRIBUTION (%)		
BOULDERS >12 inches(30cm)	0-1	0
COBBLES 3 to 12 inches(8to 30cm)	0-8	0
GRAVEL	0-61	0
SAND	25-86	13-88
SILT AND CLAY	5-33	12-87
PLASTICITY DATA		
LIQUID LIMIT	NP	36-66
PLASTICITY INDEX	NP	NP-30
COMPRESSIBILITY DATA		
COMPRESSION AT 4 ksf 192kN/m^2) (%)	DNA	1.4-2.2
SWELL OR COLLAPSE UPON SATURATION (%)	DNA	1.4-2.7 (Swell)
SHEAR STRENGTH DATA		
UNCONFINED COMPRESSION ksf(kN m^2)	DNA	2.4-4.3 (155-206)
CD TRIAXIAL COMPRESSION	c=0-8 ksf (383 kN m^2), ϕ=33-39°	c=0-4 ksf (192 kN m^2), ϕ
DIRECT SHEAR ksf(kN m^2)	2 7-10.8 (129-517)	1 2-5.2 (57-249)
COMPACTION AND CBR DATA		
MAXIMUM DRY DENSITY pcf(kg m^3)	118-122 (1890-1954)	DNA
OPTIMUM MOISTURE CONTENT (%)	9.8-11.5	DNA
CBR AT 90% RELATIVE COMPACTION	15-40	DNA

DNA = DATA NOT AVAILABLE (INSUFFICIENT DATA OR TESTS NOT PERFORMED)

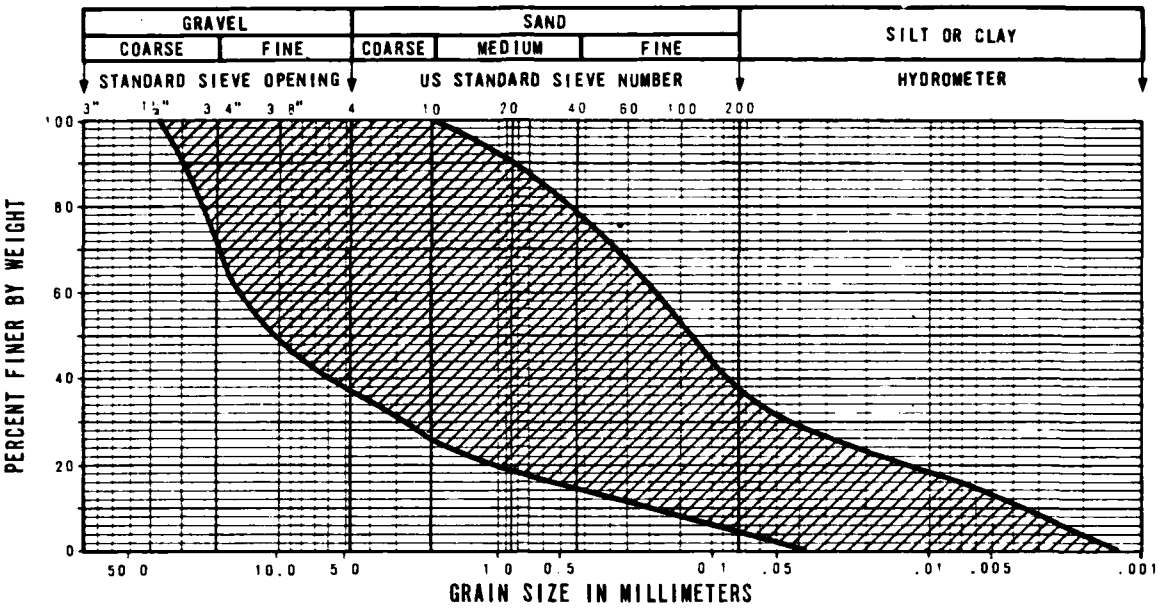
GEOLOGIC UNITS	
Playa deposits (A4)	
ML CL MH SP SM	
75-107 (1201-1714)	
6-40	
21-90	
2.56-2.59	
Uncemented to weak	
1340-5700 (408-1737)	
DNA	
0	
0	
0	
13-88	
12-87	
36-66	
NP-30	
1.4-2.2	
1.4-2.7 (Swell)	
2.4-4.3 (155-206)	
ksf (192 kN m^2), ϕ = 20-34°	
1.2-5.2 (57-249)	
DNA	
DNA	
DNA	

RANGE OF ENGINEERING AND GEOPHYSICAL PROPERTIES
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

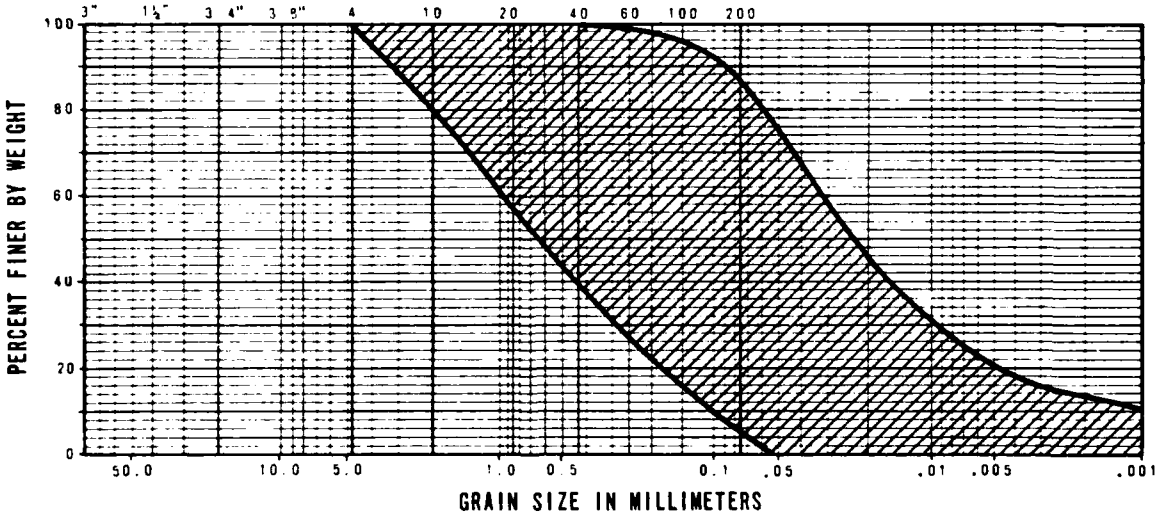
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 17

FUGRO NATIONAL, INC.



A5



A4

RANGE OF GRADATION OF GEOLOGIC UNITS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 13

FUGRO NATIONAL, INC.

FN-TR-26e

BORING/ TRENCH NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	pH	WATER SOLUBLE				CALCIUM CARBONATE
		FEET	METERS			SODIUM	CHLORIDE	SULPHATE	CALCIUM	
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
RV-B-5	P-3	15.0-15.8	4.57-4.82	SM	8.1	110	62	276	10	25
RV-B-6	P-4	20.0-20.7	6.10-6.31	SP	7.7	105	19	84	10	25
RV-T-6	B-2	5.0-6.5	1.52-1.98	ML	7.4	1100	741	1480	88	220
RV-T-7	B-1	0.0-0.5	0.00-0.15	ML	7.0	650	727	88	144	360
RV-T-8	B-2	2.5-4.5	0.76-1.37	SP	7.6	125	238	825	72	180
RV-B-9	SS-2	10.0-10.2	3.05-3.11	SM	7.6	125	110	166	51	128
RV-T-10	B-2	5.0-6.0	1.52-1.83	SP-SM	7.8	840	437	1380	52	130
RV-B-15	SS-2	14.0-15.0	4.27-4.57	SW-SM	7.7	183	133	41	5	12

SUMMARY OF CHEMICAL TEST RESULTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

TABLE 18

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

UGRO NATIONAL, INC.

4.0 SACRAMENTO VALLEY SITE

The Sacramento Valley Characterization Site covers an area of 360 nm^2 (1235 km^2) southwest of Kingman in western Mojave County, Arizona. The site consists of two contiguous valleys, the Sacramento Valley to the east and the Mojave Valley to the west. The Sacramento Valley site is bounded by State highway 68 on the north, by the Hualapai Mountains and longitude 114 00' W. on the east, and the Black and Mojave Mountains on the west and south. The Mojave Valley area was found unsuitable after preliminary field investigations and, except for the surficial geology map, the area is not considered in this report. Paved highway access is provided by State highway 68, Interstate 40, and the Kingman-Oatman Road. Graded roads and four-wheel drive trails are also present within the site.

4.1 SCOPE OF INVESTIGATION

Scope of geologic, geophysical, and soils engineering field activities performed at the site and laboratory tests performed on soil samples from the site is presented in Table 19. Detailed information about the soils engineering field activities (11 borings and eight trenches) is summarized in Tables 20 and 21. Locations of all the field activities are shown in Figure 14.

4.2 SURFICIAL GEOLOGY AND TERRAIN

Alluvial fan deposits of intermediate age are the predominant surficial geologic unit at the site, covering approximately 74 percent of the area. Of this amount, 17 percent is covered by a thin (generally less than 20 feet; 6 m) veneer of younger

GEOLOGY AND GEOPHYSICS

TYPE OF ACTIVITY	NUMBER OF ACTIVITIES
Geological mapping stations	37
Shallow refraction	14
Conductivity	14
Gravity survey	600

ENGINEERING

NUMBER OF BORINGS	NOMINAL DEPTH FEET (METERS)
6	50 (15)
4	100 (30)
1	300 (91)

NUMBER OF TRENCHES	NOMINAL DEPTH FEET (METERS)
3	6 (2)
5	11 (3)

ENGINEERING-LABORATORY TESTS

TYPE OF TEST	NUMBER OF TESTS
Moisture/density	117
Specific gravity	4
Sieve analysis	44
Hydrometer	3
Atterberg limits	5

TYPE OF TEST	NUMBER OF TESTS
Triaxial compression	9
Direct shear	15
Compaction	2
CBR	2
Chemical analysis	6

SCOPE OF FIELD AND LABORATORY ACTIVITIES
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 19

FUGRO NATIONAL, INC.

BORING NUMBER	TOTAL DEPTH FEET (METERS)	TYPE OF DRILL RIG USED	TYPE OF SAMPLES* OBTAINED
SV-B-1	100.0 (30.5)	Rotary Wash	P,D,B
SV-B-3	50.4 (15.4)	Hollow Stem Auger	D,B
SV-B-4	50.5 (15.4)	Rotary Wash	D
SV-B-5	101.3 (30.9)	Rotary Wash	P,D,B
SV-B-6	50.2 (15.3)	Hollow Stem Auger	D,B
SV-B-7	101.0 (30.8)	Rotary Wash	D,B
SV-B-8	50.5 (15.4)	Hollow Stem Auger	D,B
SV-B-10	50.0 (15.2)	Rotary Wash	D
SV-B-11	50.7 (15.5)	Hollow Stem Auger	D,B
SV-B-12	302.5 (92.2)	Rotary Wash	P,D,B
SV-B-14	100.0 (30.5)	Rotary Wash	D,B

*P = Pitcher Sample (undisturbed)
D = Fugro Drive Sample (relatively undisturbed)
B = Bulk Sample (disturbed, but representative)

ENGINEERING FIELD ACTIVITIES - BORINGS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 20

FUGRO NATIONAL, INC.

TRENCH NUMBER	TOTAL DEPTH FEET(METERS)	STABILITY OF VERTICAL EXCAVATION WALLS AND REMARKS
SV-T-2	12.0 (3.7)	0-12' (0-3.7m) stable
SV-T-3	5.9 (1.8)	0-5.9' (0-1.8m) stable; cemented layer at 5.9' (1.8m); backhoe* could not excavate the cemented layer
SV-T-4	12.0 (3.7)	0-3.4' (0-1.0m) stable; stage I caliche layer at 1.4-3.4' (0.4-1.0m) 3.4-6.0' (1.0-1.8m) unstable 6.0-12.0' (1.8-3.7m) stable
SV-T-6	10.5 (3.2)	0-8.0' (0-2.4m) unstable 8.0-10.5' (2.4-3.2m) stable; stage I to stage II caliche layer; cementation at 10.5' (3.2m) exceeded capacity of backhoe*
SV-T-7	11.0 (3.4)	0-11' (0-3.4m) stable; stage I to stage II caliche 2.5-11.0' (0.8-3.4m)
SV-T-10	12.0 (3.7)	0-2.5' (0-0.8m) unstable 2.5-12.0' (0.8-3.7m) stable; stage I caliche layer at 2.5-10.0' (0.8-3.0m); stage II caliche layer at 10.0-12.0' (3.0-3.7m)
SV-T-11	6.4 (2.0)	0-1.0' (0-0.3m) unstable 1.0-6.4' (0.3-2.0m) stable; cementation at 6.4' (2.0m) exceeded capacity of backhoe*
SV-T-12	6.7 (2.0)	0-6.7' (0-2.0m) stable; stage II caliche layer at 6.7' (2.0m) exceeded capacity of backhoe*

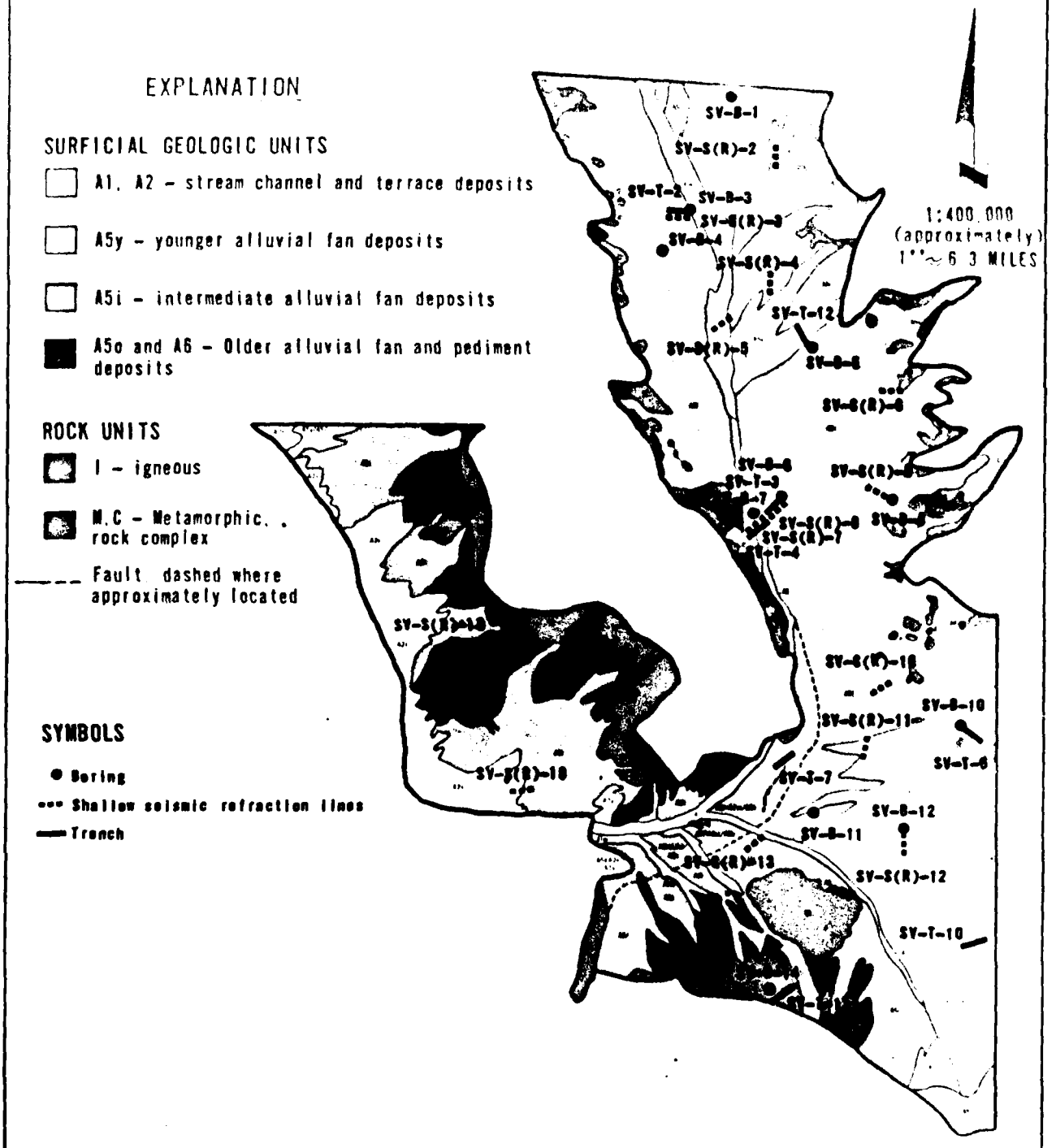
*John Deere 400

ENGINEERING FIELD ACTIVITIES - TRENCHES
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 21

UGRO NATIONAL, INC.



NOTES:

- Field data are limited northwest of Sacramento Wash due to unsuitable terrain conditions
- For detailed description of geologic units, see Table A-1.

GENERALIZED GEOLOGIC MAP AND
FIELD ACTIVITY LOCATIONS
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIG. NO. 14

FUGRO NATIONAL, INC.

alluvial fan deposits. Younger alluvial fan deposits greater than 20 feet (6 m) thick cover another nine percent of the area. The site is characterized by an open drainage system and contains no playa deposits.

The intermediate alluvial fan deposits are typically silty gravelly sands ranging from silty sands to sandy gravels with cobbles and boulders. Younger alluvial fan deposits are generally silty sands with local gravel. The surficial geologic units are described in Table 22.

The maximum surface slope is ten percent with typical slopes of four percent. Depths of drainage incision (excluding older alluvial fan deposits) range from zero to 30 feet (0 to 9 m) with typical depths of ten feet (3 m).

4.3 SUBSURFACE CONDITIONS

4.3.1 Soil Profiles

The composition of soils with depth is illustrated by the soil profiles shown in Figures 15 and 16. The dominant valley soils are silty sands and gravelly sands, which interbed with sandy gravels near the mountain fronts. Cobbles and boulders are occasionally found near the mountain fronts. Cementation of the soils generally increases with age of soil. Sandy soils at shallow depths are generally uncemented to weakly cemented, often caving in unshored vertical trench excavations.

4.3.2 Depth to Shallow (<150 ft; <46 m) Rock and Water

Figure 17 shows portions of the site in which rock (seismic

SURFICIAL GEOLOGIC UNIT (a)	GEOLOGIC AGE	THICKNESS FEET (METERS)	DESCRIPTIVE NAME(S)	USCS SYMBOL(S) (b)	AREAL EXTENT (SITE)	
					nm^2 (km^2)	PERCENT
Fluvial Deposits (Al)	Holocene	Unknown	Sand	SP	25 (86)	7
Stream Terrace Deposits (A2s)	Quaternary-Tertiary (?)	Unknown	Gravelly Sand	SP-SM	13 (45)	4
Younger Alluvial Fan Deposits (A5y)	Holocene	Unknown	Silty Sand	SM	34 (117)	9
Intermediate Alluvial Fan Deposits (A5i)	Pleistocene	Unknown	Silty Gravelly Sand	SM	264 (905)	74
Older Alluvial Fan Deposits (A5o)	Pleistocene	Unknown	Sandy Gravel	GW, GP, SM(?)	23 (79)	6

NOTES:

Area calculations and unit descriptions are from Sacramento Valley proper excluding the area north and west of the designated line shown in Figures 14 and 17

(a) For generic description of geologic units, see Table A-1.

(b) For description of USCS symbols, see Table A-2.

(c) For description of stage of caliche, see Figure A-1.

(d) Includes four percent Alluvial Outwash deposits (Alw) which consists of mixed Al and A5y or A5i deposits.

(e) Mapped as A5i(A2s)/A2s on Figures 14 and 17

(f) Includes seventeen percent A5y/A5i and one percent A6 (areas underlain by shallow rocks) as shown on Figures

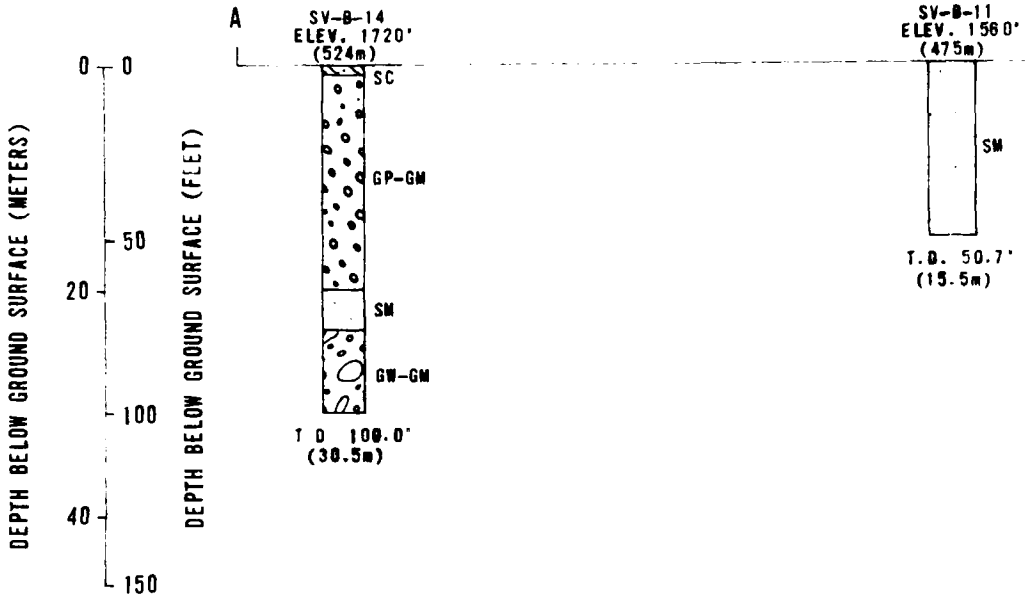
EAL EXTENT (SITE)		PROPERTIES OF SURFACE MATERIALS					SURFACE MORPHOLOGY		NOTES
^{2} (km^2)	PERCENT	GRADATION	CEMENTATION	MAXIMUM GRAIN SIZE	PAVEMENT/ PATINA	STAGE OF CALICHE (c)	SLOPE (PERCENT)	DRAINAGE DEPTHS FEET (METERS)	
25 (86)	7	Poor	Weak	Boulder	None / None	None-I	<1	0-1 (0-0.3)	(d)
13 (45)	4	Moderate	Strong (Silica)	Cobble	Moderate / Poor	None	2-6	10-30 (3-9)	(e)
34 (117)	9	Moderately Poor	Weak	Cobble	None-Poor / None	None-I	1-3	0-5 (0-1.5)	
264 (905)	74	Moderately Poor to Moderately Well	Weak to Moderate	Boulder	Moderate / None-Well	I-II	2-6	3-30 (1-9)	(f)
23 (79)	6	Moderate to Well	Strong to Very Strong	Boulder	Moderate / Moderate	II-III	4-10	15-100 (5-30)	

DESCRIPTION OF SURFICIAL GEOLOGIC UNITS
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 22

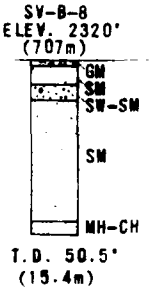
FUGRO NATIONAL, INC.

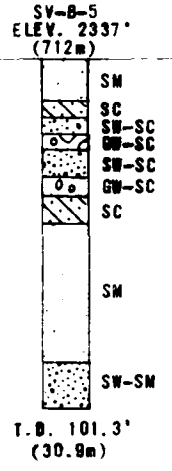


STATUTE MI

KILOMETERS

NOTES:
1. Ground surface elevations shown at locations of borings are approx
2. T.D. = Total Depth
3. Soil types shown adjacent to soil column are based on Unified Soil and are explained in the appendix





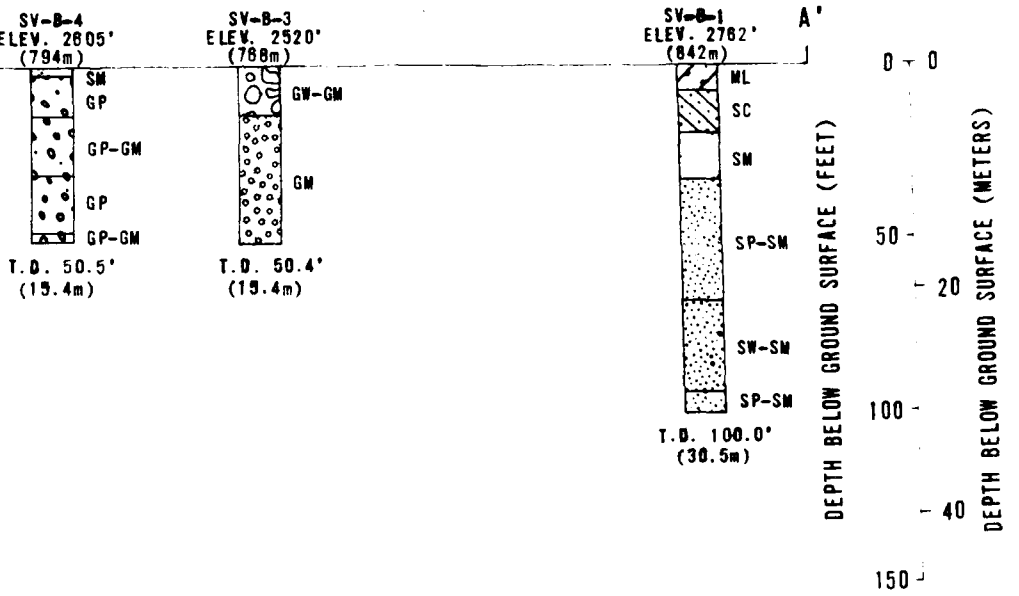
HORIZONTAL SCALE

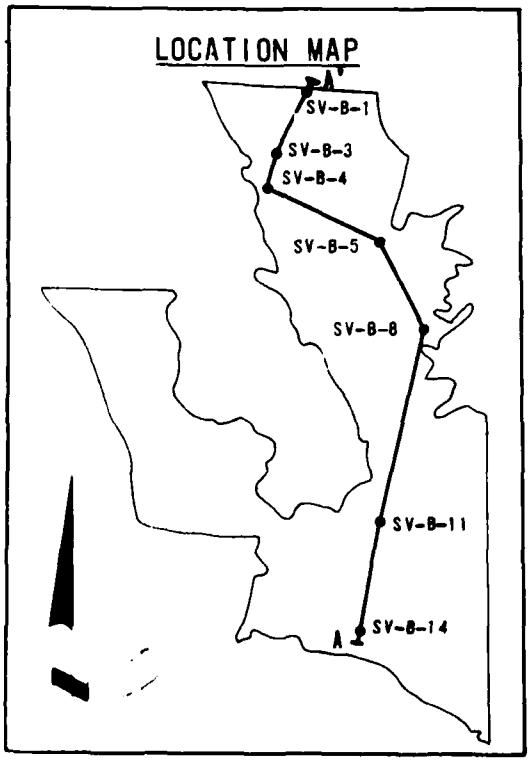
E MILES 0 2 4

TERS 0 2 4 6

proximate

Soil Classification System (USCS)

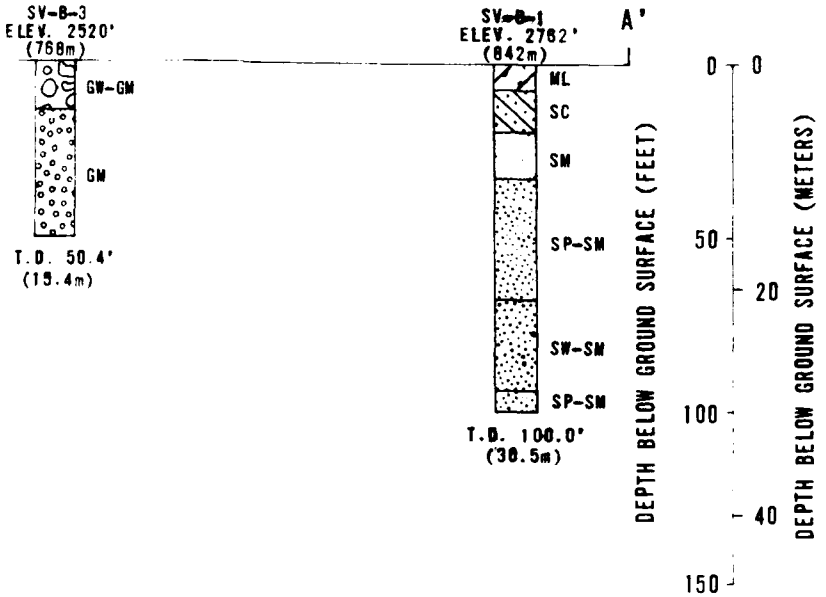




SOIL PROFILE AA'
SACRAMENTO VALLEY, ARIZO
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FUGRO NATIONAL



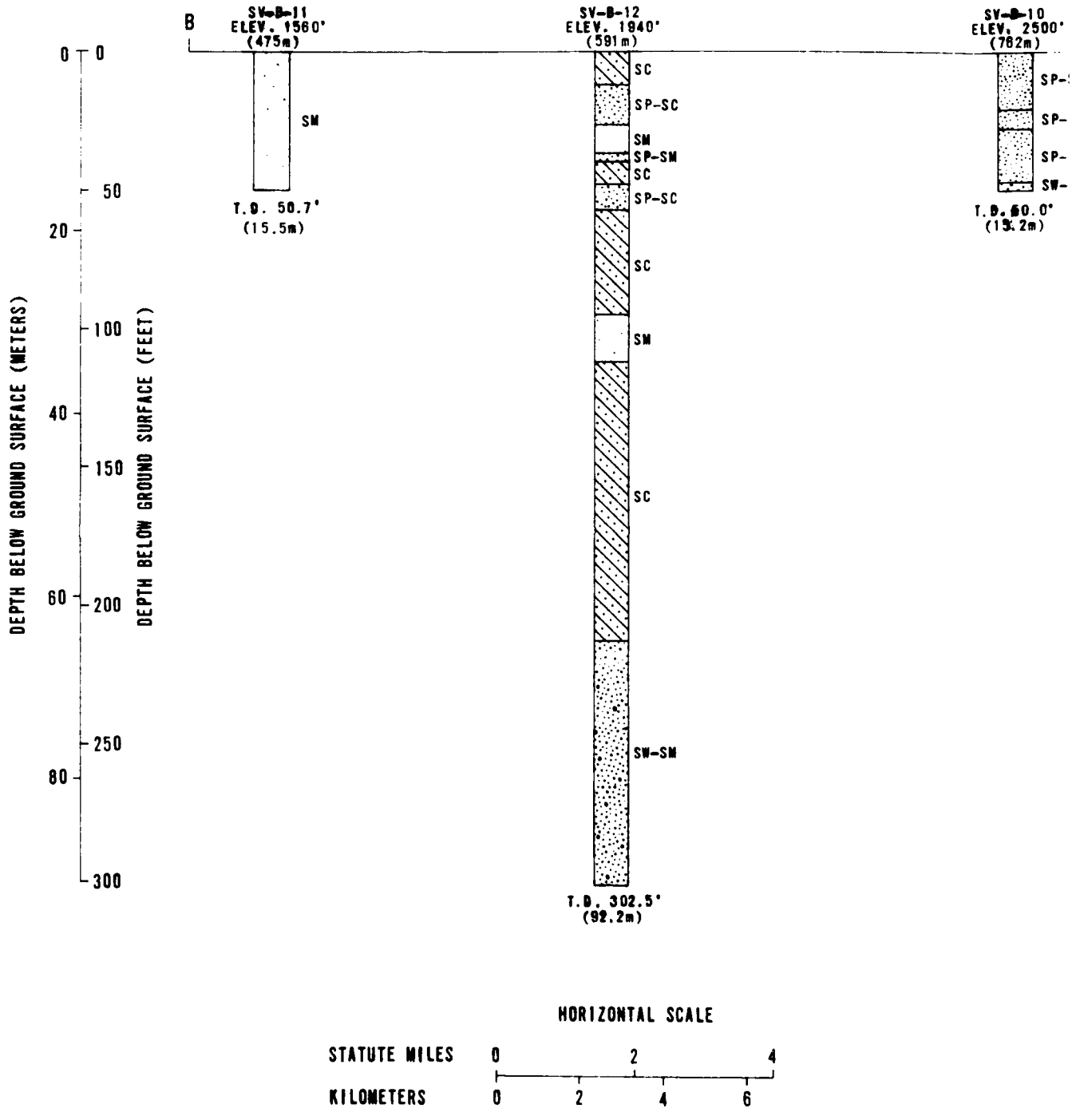
SOIL PROFILE AA'
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

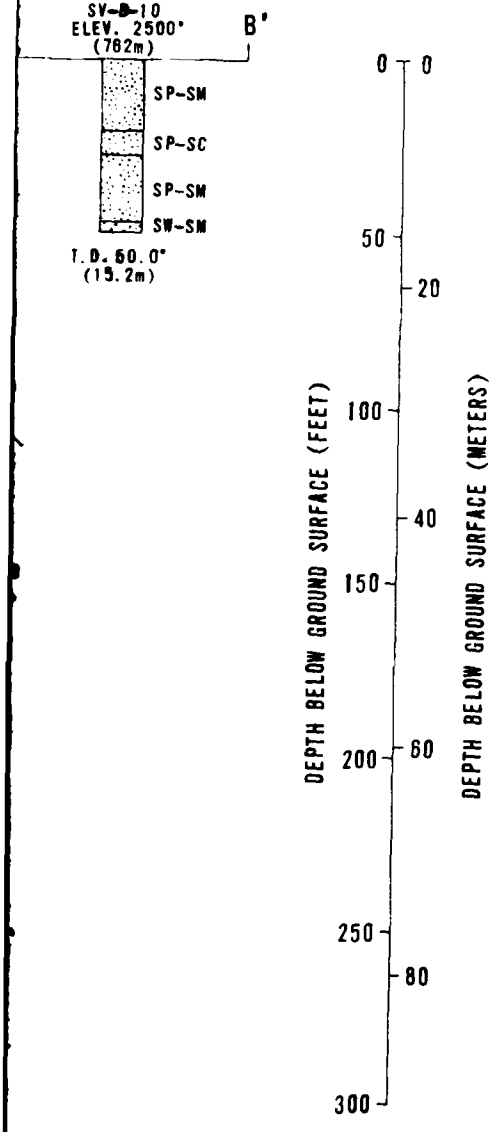
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

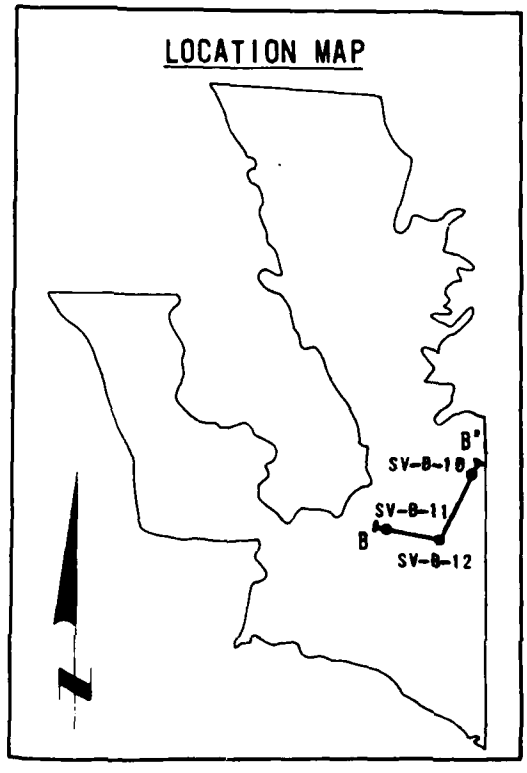
FIGURE
15

4

UGRO NATIONAL, INC.


B
SV-B-11
ELEV. 1560'
(475m)
SV-B-12
ELEV. 1940'
(591m)
SV-B-10
ELEV. 2500'
(762m)
SM
T.D. 50.7'
(15.5m)
SC
SP-SC
SM
SP-SM
SC
SP-SC
SC
SM
SC
SW-SM
T.D. 302.5'
(92.2m)
SP-
SP-
SP-
SW-
T.D. 50.0'
(15.2m)
DEPTH BELOW GROUND SURFACE (METERS)
DEPTH BELOW GROUND SURFACE (FEET)
0
50
20
100
40
150
60
200
250
80
300
HORIZONTAL SCALE
STATUTE MILES
0
2
4
KILOMETERS
0
2
4
6





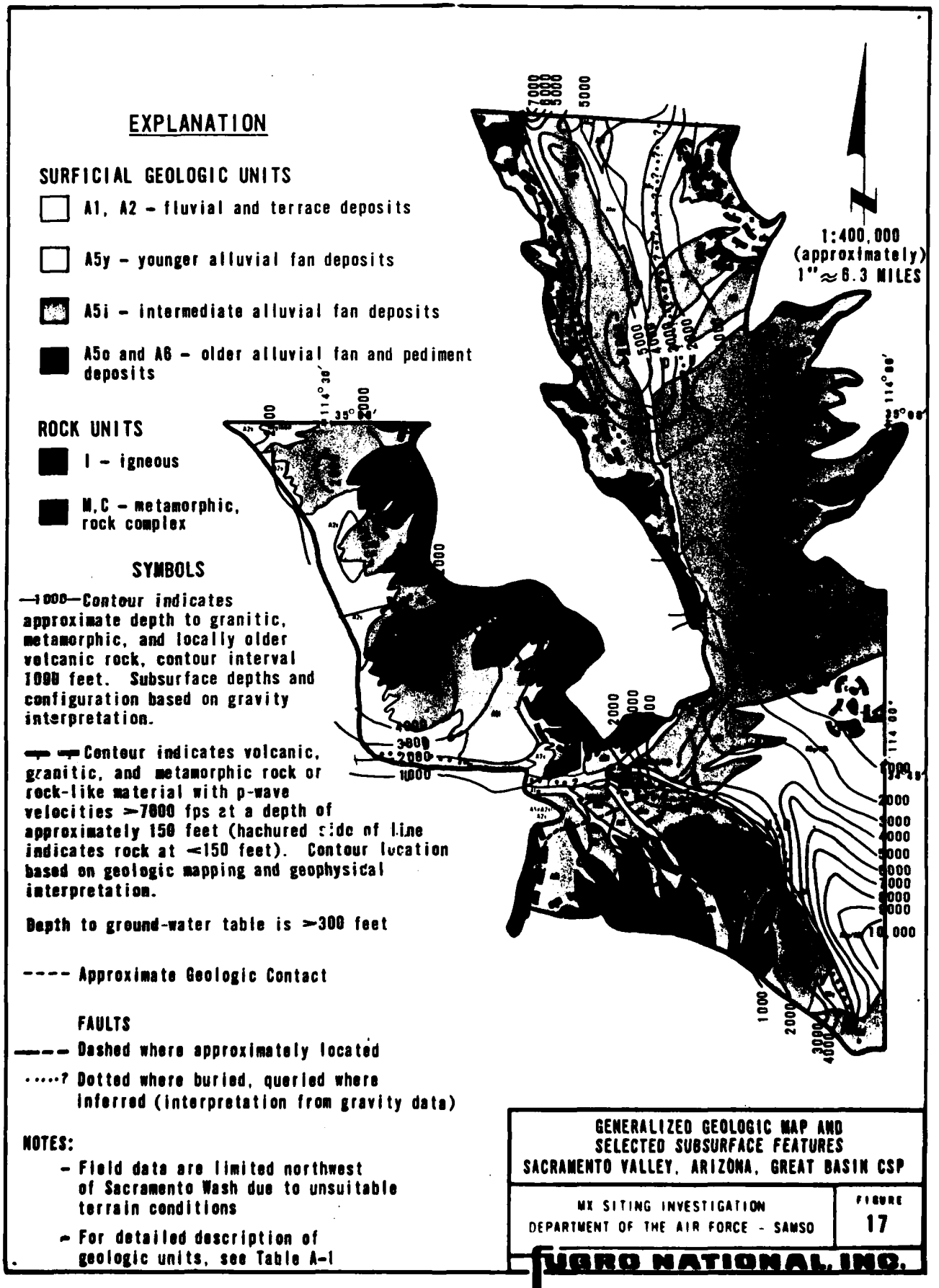
NOTES:
1. Ground surface elevations shown at locations of borings are approximate
2. T.D. = Total Depth
3. Soil types shown adjacent to soil column are based on Unified Soil Classification System (USCS) and are explained in the appendix

SOIL PROFILE BB'
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE 16

FUGRO NATIONAL, INC.


EXPLANATION
SURFICIAL GEOLOGIC UNITS
A1, A2 – fluvial and terrace deposits
A5y – younger alluvial fan deposits
A5i – intermediate alluvial fan deposits
A5o and A6 – older alluvial fan and pediment deposits
ROCK UNITS
I – igneous
M,C – metamorphic, rock complex
SYMBOLS
—1000— Contour indicates approximate depth to granitic, metamorphic, and locally older volcanic rock, contour interval 1000 feet. Subsurface depths and configuration based on gravity interpretation.
Contour indicates volcanic, granitic, and metamorphic rock or rock-like material with p-wave velocities ≥7000 fps at a depth of approximately 150 feet (hachured side of line indicates rock at <150 feet). Contour location based on geologic mapping and geophysical interpretation.
Depth to ground-water table is ≥300 feet
Approximate Geologic Contact
FAULTS
Dashed where approximately located
Dotted where buried, queried where inferred (interpretation from gravity data)
NOTES:
– Field data are limited northwest of Sacramento Wash due to unsuitable terrain conditions
– For detailed description of geologic units, see Table A-1
1:400,000 (approximately) 1" ≈ 6.3 MILES
GENERALIZED GEOLOGIC MAP AND SELECTED SUBSURFACE FEATURES
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO
FIGURE 17
FUGRO NATIONAL, INC.

velocities greater than 7000 fps; 2134 mps) is estimated to be encountered within a depth 150 ft (46 m) below the ground surface. This area with shallow rock covers approximately ten to 15 percent of the area. This analysis is based on data and interpretation from borings, seismic surveys, gravity surveys, surface outcrops, topography, and geologic maps. Ground water is nowhere less than 150 feet (46 m) below the surface and generally greater than 300 feet (91 m) based on regional water well data.

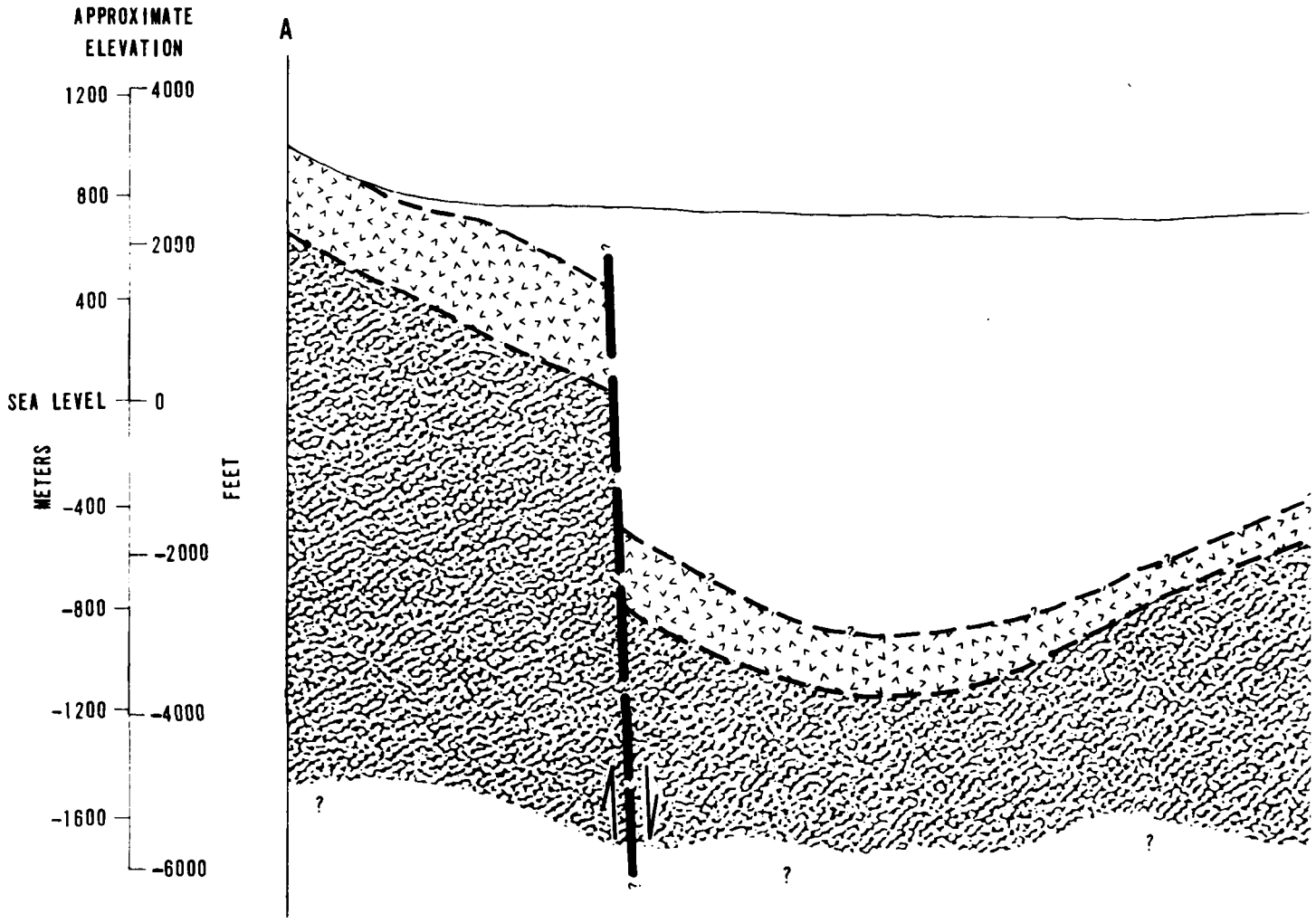
4.3.3 Basin Configuration

Data from seismic refraction and gravity surveys were used in interpreting basin configuration. Gravity data indicate greatest depth to basement to be approximately 10,000 feet (3048 m) below the surface near the southeastern boundary of the site (Figure 17). The basement surface on which the gravity is interpreted is probably a Precambrian surface below the basin-fill deposits though locally, this interpretation may be due to a dense volcanic surface. The cross-section (Figure 18) is drawn in the northern part of the site where the depth to basement is only 6000 feet (1829 m). The basin in this area is bounded by gravity gradients similar to those associated with normal faults, with relative movement down on the basinward side. The basin configuration is illustrated in Figures 17 and 18.

4.4 GEOPHYSICAL PROPERTIES

Results of shallow seismic and conductivity measurements are presented in Tables 23 and 24, respectively. Seismic compres-~~sional~~ wave velocities ranged from 990 to 8540 fps (302 to

Shear



EXPLANATION

NOTES:

1. The cross section is generally representative of subsurface conditions within the band shown on the location map. Due to the limited density of available data and the sparseness of newly acquired data, the subsurface conditions are highly interpretive.
2. For a detailed description of geologic units see Table A-1.

Undifferentiated basin-fill deposits
Predominantly alluvial (A5) deposits, with fluvial (A1) and stream terrace (A2s) deposits

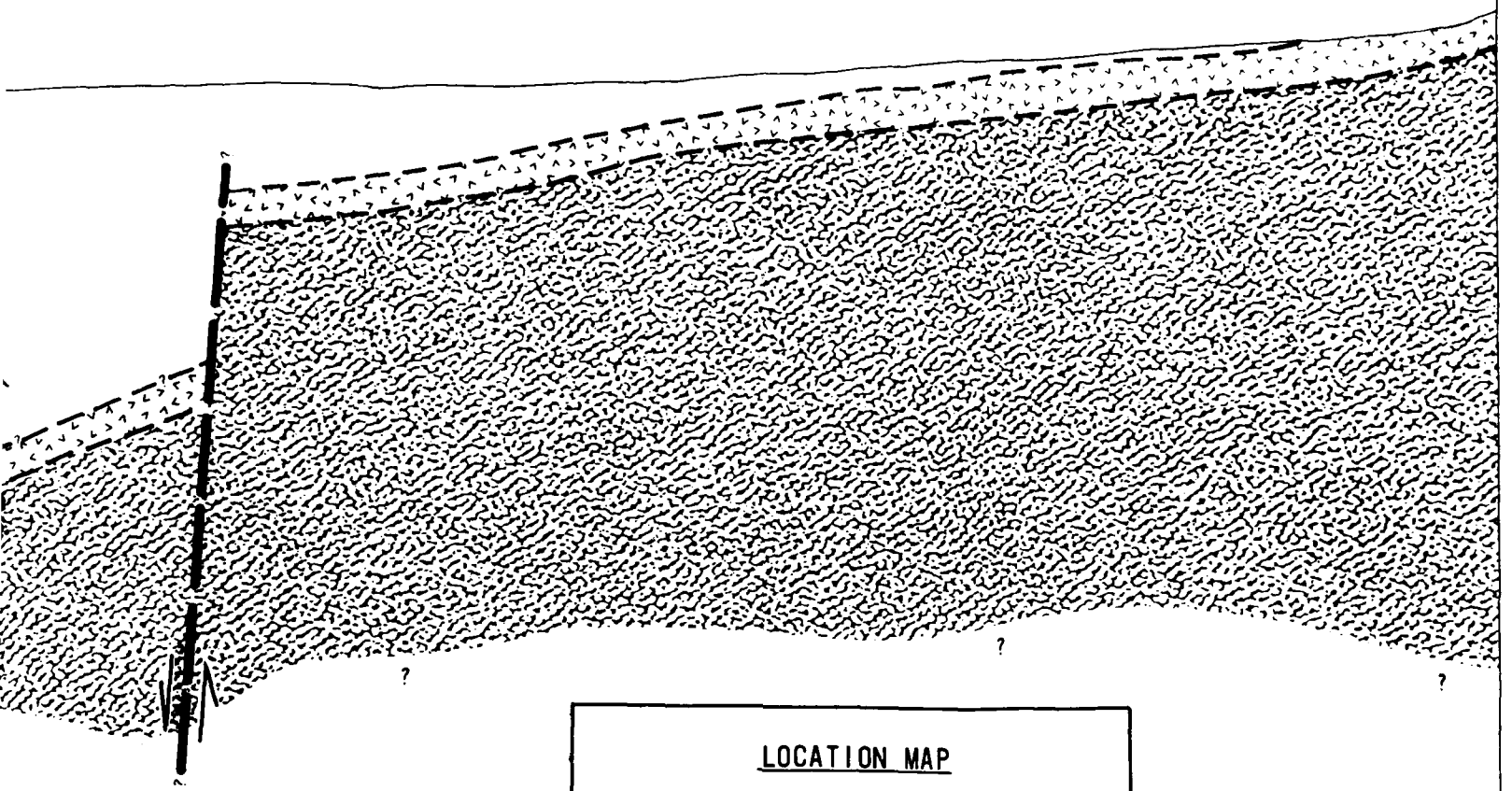
Volcanic rock
Volcanic flows and volcanoclastic rock of Tertiary age

Precambrian granitic rock

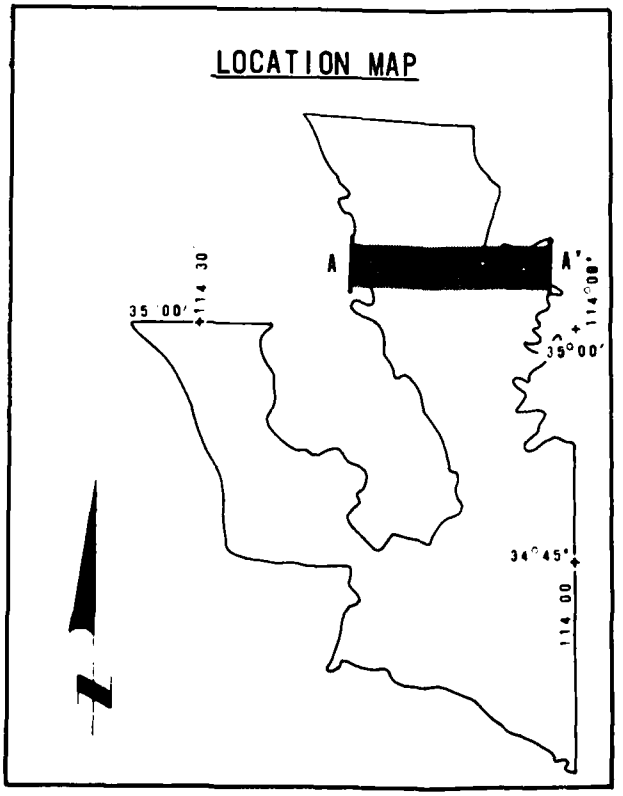
Approximate geologic contact, queried where inferred

Fault, dashed where inferred from gravity interpretation

A'



LOCATION MAP



Horizontal Scale: 1
Vertical Scale: 1"
Vertical Exaggerate

STATUTE MILES 0

KILOMETERS 0

GENERALIZED
SACRAMENT
GREA

MX SITING
DEPARTMENT OF THE

FUGRO N

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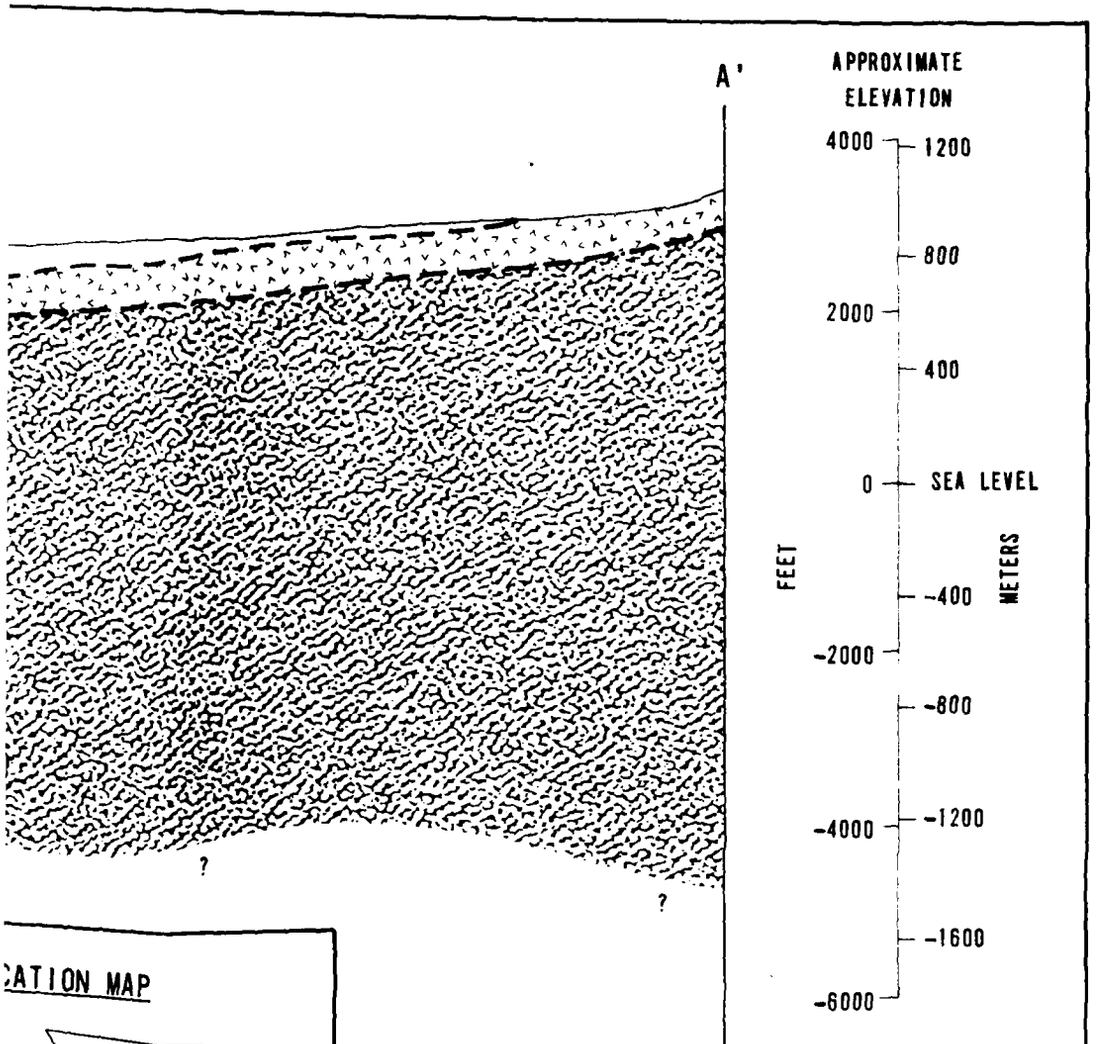
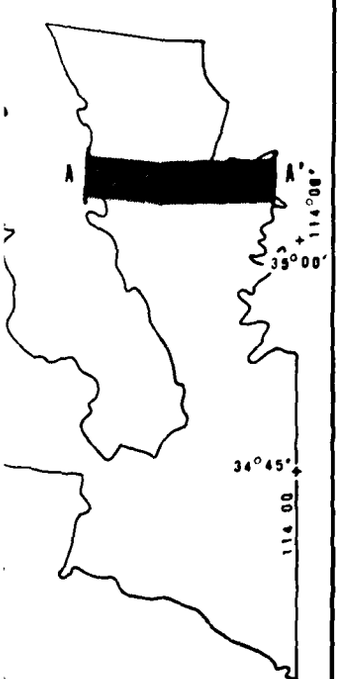
y age

tion

2.



CATION MAP



Horizontal Scale: 1" ≈ 1 Mile (3km)
Vertical Scale: 1"= 2000' (610m)
Vertical Exaggeration: 2.6X

HORIZONTAL SCALE

STATUTE MILES 0 1 2

KILOMETERS 0 1 2 3

GENERALIZED GEOLOGIC CROSS SECTION
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
18

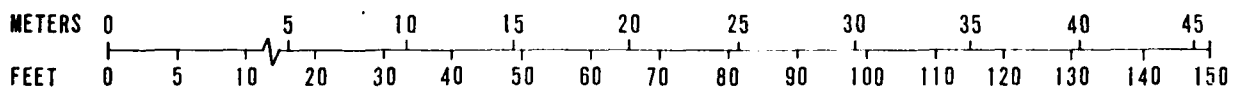
FUGRO NATIONAL, INC.

3

FN-TR-26a

SEISMIC LINE NO.	VELOCITY DISTRIBUTION FPS (MPS)	DEEPER REFRACTORS DEPTH / VELOCITY	* ROCK EXCLUSION DEPTH TO 7000 FPS (2134 MPS)
SV-S-2	990 (302) / 2830 (863) / 3490 (1064)	-	131 (40)
SV-S-3	(a) / 3310 (1009) / 4460 (1359)	-	120 (37)
SV-S-4	(b) / 3880 (1183)	-	124 (38)
SV-S-5	3850 (1173) / 4750 (1448)	-	95 (29)
SV-S-6	(c) / 4370 (1332) / 6670 (2033) / 8540 (2603)	-	-
SV-S-7	1040 (317) / 3690 (1125) / 7550 (2301)	-	-
SV-S-8	(d) / 5200 (1585)	-	116 (35)
SV-S-9	3170 (966) / 4200 (1280)	-	122 (37)
SV-S-10	1670 (509) / 2880 (878) / 5980 (1823)	-	131 (40)
SV-S-11	2100 (640) / 2820 (860)	-	144 (44)
SV-S-12	(e) / 2620 (799)	-	142 (43)
SV-S-13	1490 (454) / 3120 (951) / 4470 (1362)	-	121 (37)
SV-S-18	1560 (475) / 3160 (963) / 4260 (1298)	-	149 (45)
SV-S-19	2090 (637) / 3230 (985) / 4420 (1347)	-	132 (40)
		FT (M) / FPS (MPS)	FEET (M)

NOTE: (a) 1440 (439) (b) 1550 (472) (c) 1650 (503) (d) 1730 (527) (e) 1320 (402)



* If no refracting interface or layer with a velocity greater than 7000 fps (rock/rock-like material) was detected, a rock exclusion depth caculation was performed to determine the minimum depth at which rock could occur.

TABLE 23

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

SHALLOW SEISMIC REFRACTION RESULTS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

FUGRO NATIONAL, INC.

ACTIVITY LOCATION*	AVERAGE CONDUCTIVITY (mhos m)**
R-2	0.016
R-3	0.009
R-4	0.007
R-5	0.013
R-6	0.004
R-7	0.015
R-8	0.012
R-9	0.030
R-10	0.005
R-11	0.022
R-12	0.017
R-13	0.008
R-18	0.012
R-19	0.010

*Resistivity was determined using a Schlumberger Array at each location where a seismic refraction survey was conducted.

**Conductivity is the inverse of resistivity. Numbers presented are the average of values determined to a depth of 50 feet, computed as follows:

$$\text{Average Conductivity} = (C_1t_1+C_2t_2+\ldots.+C_nt_n)/50 \text{ feet}$$

Where

Average Conductivity = mhos/m

C_1 through C_n = Conductivity (mhos/m) of layers 1 through n

t_1 through t_n = Thickness (feet) of layers 1 through n to 50 feet

CONDUCTIVITY SURVEY RESULTS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE 24

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2603 mps). The low velocity (2000 fps; 610 mps) surficial layer was less than ten feet (3 m) thick. Velocities greater than 7000 fps or 2134 mps (considered rock) were only observed at depths of 71 and 38 feet (22 and 12 m) at SV-S-6 and SV-S-7, respectively. Average electrical conductivities for the upper 50 feet (15 m) of soil ranged from 0.004 to 0.022 mhos/m. All exceeded the minimum value of 0.004 mhos/m specified in the Fine Screening criteria except at SV-R-6 which was equal to the minimum.

4.5 ENGINEERING PROPERTIES

Engineering properties of the subsoils were determined from laboratory tests. The tests included the following; classification, shear strength, compaction, CBR, and chemical. The range of engineering and geophysical properties of predominant geologic units is presented in Table 25.

Younger and intermediate alluvial fan deposits are combined into one unit since they could not be differentiated at depth. In addition, these two units have similar grain-size and engineering properties. These alluvial fan deposits consist predominantly of dense to very dense silty sands and sandy gravels possessing moderately high shear strengths. Range of gradation of the alluvial fan deposits is shown in Figure 19. Results of chemical tests on soil samples are presented in Table 26. The test results indicate that sulfate attack of soils on concrete will be "positive" in most areas of the site.

Representative logs of three borings and three trenches from the site are contained in Appendix D. Results of the shear strength

ENGINEERING AND GEOPHYSICAL PROPERTIES	Intermediate and younger alluvial fan deposits (A5i and A5y)
UNIFIED SOIL CLASSIFICATION SYMBOL(S)	SM, SC, SP, SW, GP, GM, GW
GENERAL PROPERTIES	
DRY DENSITY pcf(kg m^3)	94–132 (1506–2118)
MOISTURE CONTENT (%)	2–16
DEGREE OF SATURATION (%)	15–82
SPECIFIC GRAVITY	2 60–2 73
DEGREE OF CEMENTATION	Uncemented to moderate
COMPRESSIONAL WAVE VELOCITIES fps(mps)	990–8540 (302–2603)
ELECTRICAL CONDUCTIVITY (mhos m)	0 004–0 022
GRAIN SIZE DISTRIBUTION (%)	
BOULDERS >12 inches (30cm)	0–10
COBBLES 3 to 12 inches (8 to 30cm)	0–26
GRAVEL	2–86
SAND	14–98
SILT AND CLAY	1–39
PLASTICITY DATA	
LIQUID LIMIT	DNA
PLASTICITY INDEX	DNA
COMPRESSIBILITY DATA	
COMPRESSION AT 4 ksf (192kN m^2) (%)	DNA
SWELL OR COLLAPSE UPON SATURATION (%)	DNA
SHEAR STRENGTH DATA	
UNCONFINED COMPRESSION ksf(kN m^2)	DNA
CD TRIAXIAL COMPRESSION	C = 0–2 5 ksf (144 kN/ m^2) ϕ = 33 –40
DIRECT SHEAR ksf(kN m^2)	2 4–10 3 (115–493)
COMPACTION AND CBR DATA	
MAXIMUM DRY DENSITY pcf(kg m^3)	119–131
OPTIMUM MOISTURE CONTENT (%)	8 0–11 5
CBR AT 90% RELATIVE COMPACTION	19 ±

DNA = DATA NOT AVAILABLE (INSUFFICIENT DATA OR TESTS NOT PERFORMED)

GEOLOGIC UNIT	
...nd A5y)	

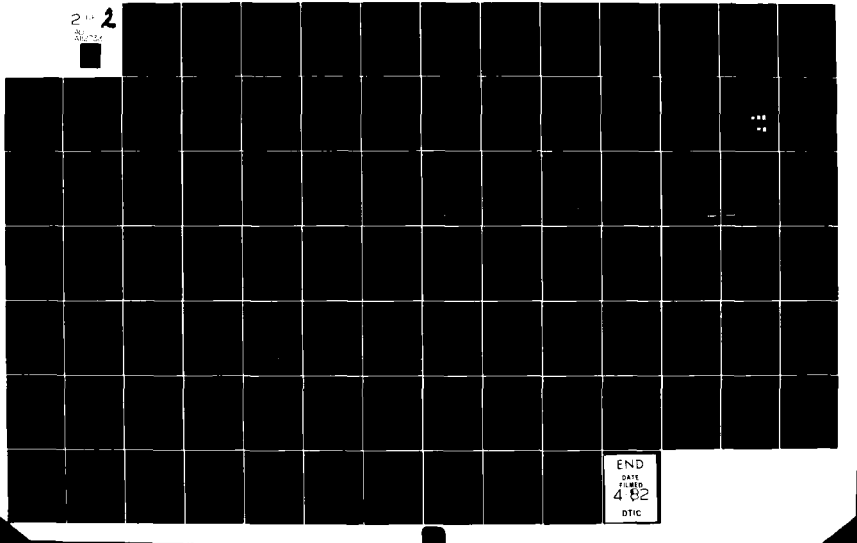
RANGE OF ENGINEERING AND
GEOPHYSICAL PROPERTIES
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE
25

FUGRO NATIONAL, INC.

AD-A112 733 FUGRO NATIONAL INC LONG BEACH CA F/G 8/7
MX SITING INVESTIGATION. GEOTECHNICAL SUMMARY. PRIME CHARACTERI--ETC(U)
FEB 79 F04704-77-C-0010
UNCLASSIFIED FN-TR-26E NL



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4-82
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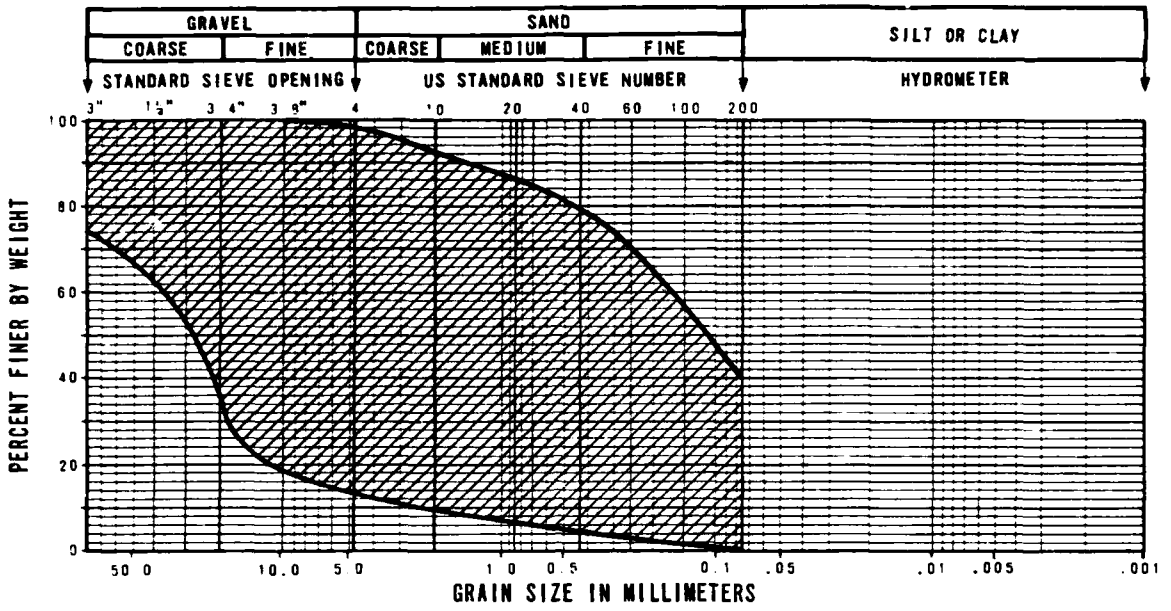
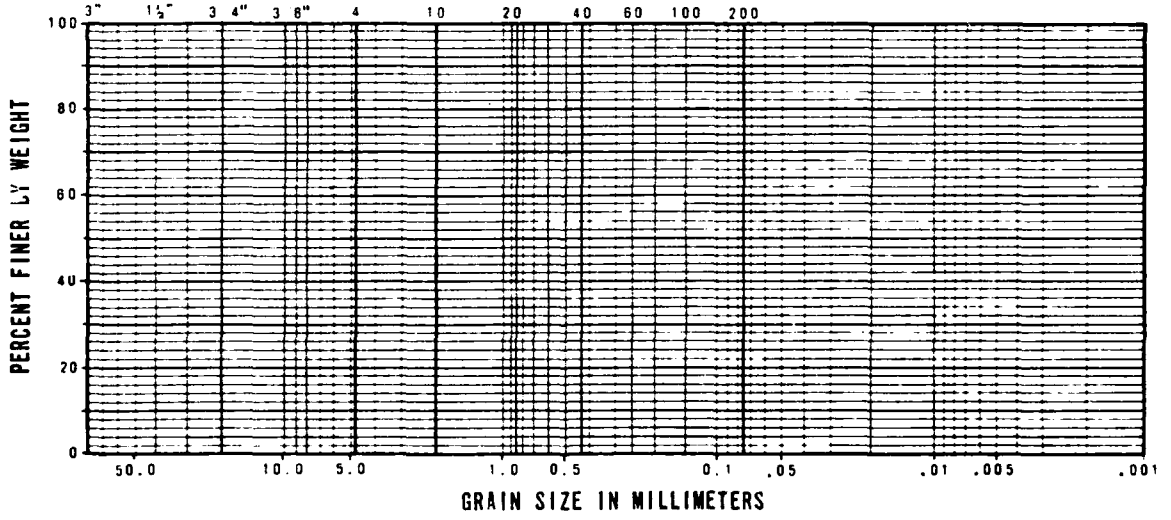


A5



RANGE OF GRADATION OF GEOLOGIC UNITS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE 19

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BORING / TRENCH NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	pH	WATER SOLUBLE				CALCIUM CARBONATE
		FEET	METERS			SODIUM	CHLORIDE	SULPHATE	CALCIUM	
						mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
SV-B-1	D-3	5.7-6.4	1.74-1.95	ML	7.5	340	61	1520	360	504
SV-B-5	D-4	9.7-10.4	2.96-3.17	SM	8.8	1800	490	1880	340	348
SV-B-7	D-4	10.7-11.4	3.26-3.47	SW-SM	7.1	520	260	1220	83	219
SV-B-10	D-5	17.7-18.4	5.40-5.61	SP-SM	5.9	140	80	750	73	508
SV-B-12	P-6	20.7-21.5	6.31-6.55	SP-SC	6.9	920	520	1800	1730	301
SV-B-14	D-4	15.6-16.0	4.75-4.88	GP-GM	6.4	600	360	2170	130	394

SUMMARY OF CHEMICAL TEST RESULTS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE 26

FUGRO NATIONAL, INC.

and CBR tests performed on soil samples from the site and a summary of all the laboratory tests performed on soil samples obtained from boring SV-B-12 are also included in Appendix D.

5.0 DISCUSSION

Analysis of the geotechnical data shows similar and dissimilar features between all three sites. In general, Dry Lake and Ralston valleys are similar and may be used to characterize an area between and around the sites in central Nevada. The Sacramento Valley site is significantly different from Dry Lake and Ralston valleys and can be used to characterize scattered areas of the Great Basin CSP in Arizona and Nevada. Similarities between Dry Lake and Ralston valleys are:

- Younger and intermediate alluvial fan deposits are the predominant surficial geologic units (younger fans being dominant).
- Playa deposits, though not extensive on the surface, are a significant unit due to their thickness and central valley location.
- The basins have closed drainage.
- These valleys are generally down-dropped (relative to mountains) structural blocks bounded by potentially active faults.
- The engineering characteristics of the geologic units at the two sites are similar, however, there are differences between the areal extent of these units at each site.

Some dissimilar features between Dry Lake and Ralston are:

- Large areas of undifferentiated non-rock and playa deposits exist in the Ralston site (result of very low relief near valley center).

- o Although no eolian sand deposits are present in Dry Lake Valley, they are present in Ralston Valley and may be encountered locally in areas between and adjacent to the sites.
- o The fine grained soils in Dry Lake Valley are slightly more plastic but less extensive than those of Ralston Valley.

Sacramento Valley exhibits properties different from those in Dry Lake and Ralston valleys. The major differences are:

- o Sacramento Valley displays open drainage (the first four differences that follow can be attributed to this basic characteristic).
- o Sacramento has no playa deposits.
- o The ratio of areas of intermediate to younger alluvial fan deposits in Sacramento is greater by an order of magnitude (7.8 for Sacramento compared to 0.7 and 0.9 for Dry Lake and Ralston, respectively).
- o Depth of drainage incision is generally greater in Sacramento.
- o Surface slope is generally greater in Sacramento.
- o Alluvial deposits of Sacramento (due to granitic source) contain more sand.

Some features similar to Sacramento, Dry Lake, and Ralston valleys are:

- o Alluvial fan deposits are the predominant unit.
- o Basins are elongate, generally north-trending structural depressions with bounding normal faults (i.e. grabens).

Geotechnical conditions at the Dry Lake and Ralston sites are representative of approximately 25 percent of the CSP while conditions at the Sacramento site are representative of about eight percent of the area. Approximately two thirds of the CSP is not characterized by these three sites and a variety of conditions exist throughout this remaining portion of the CSP. For example, south and east of Dry Lake the area is typified by open drainages down-cutting into Tertiary lacustrine deposits. Northeast of Dry Lake, the area was inundated by Pleistocene Lake Bonneville and is typified by Pleistocene lacustrine deposits and associated gravel shorelines.

6.0 CONSTRUCTION CONSIDERATIONS

In this section, geotechnical factors and conditions applicable to construction of the MX system are discussed. The three basing mode concepts considered are vertical shelter, in-line hybrid trench, and horizontal shelter.

The important geotechnical factors for a vertical shelter are roads (primary and interconnecting), drainage crossings, and excavation of shelters. For the in-line hybrid trench, important geotechnical factors are excavation and backfill, roads (primary and temporary), drainage crossings, and aggregates for roads and concrete. For the horizontal shelter, roads and drainage crossings are the important geotechnical factors. A brief summary of the applicable geotechnical factors is presented in the following paragraphs.

- Terrain - Surficial slopes are typically less than four percent, requiring little preconstruction grading for roads and trenches. Depths of drainage incision are generally five to ten feet (1.5 to 3 m) minimizing the need for major drainage structures for roads and trenches.
- Roads - Few roads exist at the sites and therefore, a network of roads will have to be constructed. Approximately 90 percent of the surficial deposits are coarse-grained soils consisting of gravelly sands, silty sands, and sandy gravels. These soils have good to excellent subgrade characteristics when compacted, resulting in cost-effective road sections.

- Excavation - Most of the subsurface soils are dense, weakly to moderately cemented, and possess moderately high shear strength. Except in areas close to mountain fronts, compressional wave velocities range from 1000 to 5000 fps (305 to 1524 mps) up to depths of 150 feet (46 m) below the ground surface, indicating good excavatability. The soils are suitable for excavation of: vertical shelters by augers, continuous trenches (cast-in-place trench construction) by an MX trencher, and horizontal shelters using conventional equipment. In approximately 20 percent of the area, the excavation walls of a vertical shelter may be unstable, requiring slurry or other techniques to support them. Approximately five percent of the area has zones of concentrated cobbles and boulders where an MX trencher will not be able to excavate a trench suitable for cast-in-place construction.

  Depth to rock is greater than 150 feet (46 m) over approximately 80 to 85 percent of the sites, therefore, additional expense for excavation of vertical shelters is minimal. Depth to ground water is greater than 300 feet (92 m) in Dry Lake and Sacramento valleys and greater than 200 feet (61 m) in 90 percent of Ralston Valley, thus, ground-water problems during excavation are expected to be minimal.
- Backfill - Subsurface soils are generally suitable for backfill and compaction in trench excavations; minimum compactive effort will be required. Backfill will have to be imported from within the sites for areas of concentrated cobbles and boulders.

- Aggregates and Water - Sufficient quantities of aggregates and water required for roads and concrete are available within and/or adjacent to the sites, thus minimizing haul costs.

7.0 CONCLUSIONS

In summary, Dry Lake, Ralston, and Sacramento sites present favorable geotechnical conditions for deployment of any of the three present MX basing mode concepts. Geotechnical conditions from these three sites can be extrapolated to approximately 33 percent of the Great Basin CSP.

APPENDIX A

GENERAL GEOTECHNICAL INFORMATION

TABLE OF CONTENTS
APPENDIX A

TEXT

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF TERMS

ACTIVITY NUMBER - A designation composed of the valley abbreviation followed by the activity type and a unique number; may also be used to designate a particular location in a valley.

AEROMAGNETIC DATA - Magnetometer observations made from an airplane.

ALLUVIAL BASIN - A lowland area, generally between uplifted mountain blocks, filled with alluvial deposits.

ALLUVIAL FAN - A low, outspread, relatively flat to gently sloping mass of alluvium, shaped like an open fan or a segment of a cone, deposited by a stream (especially in a semiarid region) at the place where it issues from a narrow mountain valley upon a plain or broad valley. It is steepest near the mouth of the valley where its apex points upstream, and it slopes gently and convexly outward with gradually decreasing gradient.

ALLUVIAL FAN DEPOSITS - Alluvium deposited by a stream or other body of running water as a sorted or semisorted sediment in the form of a cone or fan at the base of a mountain slope.

ALLUVIAL PLAIN - A level or gently sloping tract or a slightly undulating land surface produced by extensive deposition of alluvium, usually adjacent to a river that periodically overflows its banks; it may be situated on a flood plain, a delta, or an alluvial fan.

ALLUVIUM - A general term for unconsolidated clay, silt, sand, gravel, and boulders deposited during relatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of a stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope.

ANOMALY - 1) A deviation from uniformity in physical properties; especially a deviation from uniformity in physical properties of exploration interest. 2) A portion of a geophysical survey which is different in appearance from the survey in general.

AQUIFER - A permeable saturated zone below the earth's surface capable of conducting and yielding water as to a well.

GLOSSARY OF TERMS (Cont.)

ARKOSIC SANDSTONE - A sandstone with considerable feldspar, such as one containing minerals from coarse-grained quartzo-feldspathic rocks (granites, granodiorites, medium or high-grade schists) or from older, highly feldspathic sedimentary rocks; specifically a sandstone containing more than 25% feldspar and less than 20% matrix material of clay, sericite, and chlorite.

ARRIVAL - An event; the appearance of seismic energy on a seismic record; a line-up of coherent energy signifying the arrival of a new wave train.

ATTERBERG LIMITS - A general term applied to the various tests used to determine the various states of consistency of fine grained soils. The four states of consistency are solid, semisolid, plastic, and liquid.

Liquid limit (LL) - The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil (ASTM D423-66).

Plastic limit (PL) - The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil (ASTM D424-59).

Plasticity index (PI) - Numerical difference between the liquid limit and the plastic limit.

BASIN-FILL MATERIAL/BASIN-FILL DEPOSITS - Heterogenous detrital material deposited in a sedimentary basin.

BEDROCK - Rock with a seismic p-wave velocity of 7000 ft (2333 m) per second or more.

BOUGUER ANOMALY - The residual value obtained after latitude, elevation and terrain corrections have been applied to gravity data.

BOULDER FIELD - Five or more rocks, each with diameters of 6 ft or more occurring within an acre.

BULK SAMPLE - A disturbed soil sample (bag sample) obtained from cuttings brought to the ground surface by a drill rig auger or obtained from the walls of a trench excavation.

c - Cohesion (Shear strength of a soil not related to inter-particle friction).

CALICHE - Gravel, sand or other material cemented principally by calcium carbonate.

GLOSSARY OF TERMS (Cont.)

CALIFORNIA BEARING RATIO (CBR) - A test performed on a specifically prepared soil sample which is useful in the design of road pavement to be supported by the soil tested (ASTM D1833-73). The load is applied on the penetration piston which is penetrated into the soil sample at a constant penetration rate. The bearing ratio reported for the soil is normally the one at 0.1 inches (2.5 mm) penetration.

CANDIDATE - One of some group of regions, areas or sites being considered for MX deployment. Removal of candidate from a specifically named region, area or site term indicates selection by SAMSO/MNND.

CANDIDATE DEPLOYMENT AREA (CDA) - An area encompassing between 500 and 1000 square nautical miles of potentially suitable land with either naturally or artificially defined boundaries designated for convenience of study, discussion and data depiction. The candidate deployment area could be composed of two to four parcels and should have a specific place name description.

CANDIDATE DEPLOYMENT PARCEL (CDP) - An area of 150 to 500 square nautical miles potentially suitable for MX siting which, when aggregated with others, forms a Candidate Deployment Area. Each parcel should have a specific geographic description. (In the Basin and Range Physiographic province a parcel may correspond to a geographic valley and in Texas to some agri-economic unit.)

CANDIDATE DEPLOYMENT SITE (CDS) - A non-specific (i.e. not finally approved) site proposed for some element of the MX system within a chosen deployment area (i.e. trench or shelter site).

CANDIDATE SITING PROVINCE (CSP) - An area potentially suitable for deployment of the MX system generally encompassing more than 6000 square nautical miles which, in a broad sense, is homogeneous with respect to most of the important characteristics governing siting of a total MX system.

CANDIDATE SITING REGION (CSR) - Potentially suitable area between 4000 and 6000 square nautical miles within one, or encompassing portions of more than one, candidate siting province which allows for full MX deployment.

GLOSSARY OF TERMS (Cont.)

CAPABLE (fault) - Movement at or near the surface at least once in the past 35,000 years, and/or more than once in the past 500,000 years, (Nuclear Regulatory Commission).

CAPROCK - A resistant, moderately to strongly cemented caliche layer forming a "cap" over less resistant layers.

CD TRIAXIAL SHEAR-A type of test to measure the shear strength of an undisturbed soil sample

CLOSED BASIN - A catchment area draining to some depression or lake within its area, from which water escapes only by evaporation.

COARSE-GRAINED - A term which applies to a soil of which more than one-half of the soil particles, by weight, are larger than 0.075 mm in diameter (passing the No. 200 U.S. size).

COARSER-GRAINED - A term applied to alluvial fan deposits which are predominantly composed of material larger than 3 inches (76 mm) in diameter.

COLLUVIAL DEPOSITS - A general term applied to any loose, heterogenous, and incoherent mass of soil material or rock fragments deposited chiefly by dislodgement and downslope transport of the material under the direct application of gravitational body stresses. Material is usually found at the base of a steep slope or cliff.

COMPACTION TEST - A type of test to determine the relationship between the moisture content and density of a soil sample which is prepared in compacted layers at various water contents (ASTM D1557-70).

COMPRESSIBILITY-Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

COMPRESSIONAL WAVE -An elastic body wave in which particle motion is in the direction of propagation; the type of seismic wave assumed in conventional seismic exploration. Also called P-wave, dilatational wave, and longitudinal wave.

CONSOLIDATION TEST - A type of test to determine the compressibility of a soil sample. The sample is enclosed in the consolidometer which is then placed in the loading device. The load is applied in increments at certain time intervals and the change in thickness is recorded.

GLOSSARY OF TERMS (Cont.)

CONTERMINOUS UNITED STATES - The contiguous 48 states.

CORE SAMPLE - A cylindrical sample obtained with a rotating core barrel with a cutting bit at its lower end. Core samples are obtained from indurated deposits and in rock.

DEBRIS FLOW - A high-density flow of mud containing abundant coarse-grained materials (boulders, cobbles, gravel, sand) that frequently result from an unusually heavy rain.

DEGREE OF SATURATION - Ratio of volume of water in soil to total volume of voids.

DETECTOR - See GEOPHONE.

DIRECT SHEAR TEST - A type of test to measure the shear strength of a soil sample where the sample is forced to fail on a predetermined plane.

DISSECTION/DISSECTED (alluvial fans) - The cutting of stream channels into the surface of an alluvial fan by the movement (or flow) of water.

DISTAL - That portion of an alluvial deposit farthest from its point of origin.

DRY UNIT WEIGHT/DRY DENSITY - Weight per unit volume of the solid particles in a soil mass.

ELECTRICAL CONDUCTIVITY - Ability of a material to conduct electrical current

ELECTRICAL RESISTIVITY - Property of a material which resists flow of electrical current

ENTRENCH - The process whereby a stream erodes downward to form a trench.

EOLIAN - A term applied to materials which are deposited by wind.

EPHEMERAL(stream) - A stream in which water flow is discontinuous and of short duration.

EXTERNAL DRAINAGE - Stream drainage system whose downgradient flow is unrestricted by any topographic impediments.

EXTRUSIVE (rock) - Igneous rock that has been ejected onto the earth's surface (e.g., lava, basalt, rhyolite, andesite; detrital material, volcanic tuff, pumice).

GLOSSARY OF TERMS (Cont.)

FAULT - A plane or zone of rock fracture along which there has been displacement.

FAULT BLOCK MOUNTAINS - Mountains that are formed by normal faulting in which the surface crust is divided into structural, partially to entirely fault-bounded blocks of different elevations.

FINE-GRAINED - A term which applies to a soil of which more than one-half of the soil particles, by weight, are smaller than 0.075 mm in diameter (passing the No. 200 U.S. size sieve).

FINER-GRAINED - A term applied to alluvial fan deposits, which are composed predominantly of material less than 3 inches (76 mm).

FLOODING/LOW ENERGY FLOW - Flood waters flowing on a slope of low gradient.

FLUVIAL DEPOSITS - Material produced by river action; generally loose, moderately well-graded sands and gravel.

FORMATION - A mappable assemblage of rocks characterized by some degree of homogeneity or distinctiveness

FREE AIR ANOMALY - Gravity data which have been corrected for latitude and elevation (free air correction) but not for the density of rock between the datum and the plane of measurement (Bouguer correction).

FUGRO DRIVE SAMPLE - A 2.50 inch (6.4 cm) diameter soil sample obtained from a drill hole with a Fugro Drive Sampler. The Fugro drive sampler is a ring-lined barrel sampler containing 12 one-inch (2.54 cm) long brass sample rings. The sampler is advanced into the soil using a drop-hammer.

GAMMA - A unit of magnetic-field intensity. A gamma is 10^{-5} oersteds; sometimes expressed (incorrectly) as 10^{-5} gauss with which it is numerically equal.

GEOMORPHOLOGY - The study, classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features.

GEOPHONE - The instrument used to transform seismic energy into electrical voltage; a seismometer, jug, or pick-up.

GLOSSARY OF TERMS (Cont.)

GRAIN-SIZE ANALYSIS (GRADATION) - A type of test to determine the distribution of soil particle sizes in a given soil sample. The distribution of particle sizes larger than 0.075mm (retained on the No. 200 sieve) is determined by sieving, while the distribution of the particle sizes smaller than 0.075 mm is determined by a sedimentation process, using a hydrometer.

GRAVEL - Particles of rock that pass a 3-in. (76.2 mm) sieve and retained on a No. 4(4.75 mm0 sieve

GRAVITY - The force of attraction between bodies because of their mass. Usually measured as the acceleration of gravity.

GRAVITY GRADIENT - The partial derivative of the acceleration of gravity with respect to distance in a particular direction, for which purpose the acceleration of gravity is considered as a scalar.

INTERIOR DRAINAGE - Stream drainage system that flows into a closed topographic low (basin).

INTRUSIVE (rock) - A rock formed by the process of emplacement of magma (liquid rock) in pre-existing rock. (e.g. granite, granodiorite, quartz monzonite).

LACUSTRINE DEPOSITS - Materials deposited in lake environment.

LINE - A linear array of observation points, such as a seismic line.

LIQUID LIMIT - See ATTERBERG LIMITS.

LOESS - A wind blown deposit predominantly silt or silty clay or clayey silt.

LOW ENERGY FLOW - See FLOODING.

MAGNETIC INTENSITY - A vector quantity measuring magnetic field strength. The unit of magnetic intensity commonly used in geophysical exploration is the gamma (see GAMMA).

MANTLED PLAYA - A playa surface or a portion of the surface that is covered with younger geologic material such as windblown sand, or alluvium.

MILLIGAL - A unit of acceleration used with gravity measurements; 1 milligal = 10^{-5} m/sec.^{2}. Abbreviated mgal.

GLOSSARY OF TERMS (Cont.)

MOISTURE CONTENT - The ratio, expressed as a percentage, of the weight of water contained in a soil sample to the oven-dry weight of the sample.

N VALUE - Penetration resistance, number of blows required to drive the standard split spoon sampler for the second and third six inches (0.15 m) with a 140 pound (63.5 kg) hammer falling 30 inches (0.76 m) (ASTM D1586-67).

OPTIMUM MOISTURE CONTENT - Moisture content at which a soil can be compacted to a maximum dry unit weight by a given compactive effort

OVERBANK FLOODING - A large flow of water that overflows the sides of A stream channel.

O - Angle of internal friction

PATINA - A dark coating or thin outer layer produced on the surface of a rock or other material by weathering after long exposure (e.g., *desert varnish*).

PAVEMENT/DESERT PAVEMENT - When loose material containing pebble-sized or larger rocks is exposed to rainfall and wind action the finer dust and sand are blown or washed away and the pebbles gradually accumulate on the surface, forming a mosaic which protects the underlying finer material from wind attack. Pavement can also develop in finer-grained materials. In this case the armored surface is formed by dissolution and cementation of the grains involved.

PEGAMATITE DIKE - A coarse grained igneous rock of granitic composition that forms as a tabular intrusion that cuts across the planar structures of the surrounding rock.

P-WAVE - See COMPRESSIONAL WAVE.

PERIMETER SEISMIC REFRACTION SURVEY - Shallow seismic refraction measurements made around the perimeter of a valley.

PERMEABLE - The ability of liquid to pass through soil and/or rock material.

PICK-UP - See GEOPHONE.

GLOSSARY OF TERMS (Cont.)

PITCHER TUBE SAMPLE - An undisturbed, 2.87 inch (73 mm) diameter soil sample obtained from a drill hole with a Pitcher tube sampler. The primary components of this sampler are an outer rotating core barrel with a bit and an inner stationary, spring-loaded, thin-wall sampling tube which leads or trails the outer barrel drilling bit, depending upon the hardness of the material being penetrated.

PLASTIC LIMIT - See ATTERBERG LIMITS.

PLASTICITY INDEX - See ATTERBERG LIMITS.

PLAYA/PLAYA DEPOSITS - A term used in the southwest U.S. for a dried-up, flat-floored area composed of thin, evenly stratified sheets of fine clay, silt, or sand, and representing the lowest part of a shallow, completely closed or undrained, desert lake basin in which water accumulates and is quickly evaporated, usually leaving deposits of soluble salts.

PONDING (of water) - The accumulating of water in a topographic depression.

PRIME - Modifier used to indicate the highest ranking province, region, area, or site. If not an interdisciplinary ranking, then a qualifier should be used such as "prime" geotechnical candidate siting area".

PROXIMAL - That portion of an alluvial deposit nearest to its point of origin.

REGIONAL - The general attitude or configuration disregarding features smaller than a given size. The regional gravity is the gravity field produced by large-scale variations ignoring anomalies of smaller size. See residualize.

RELATIVE AGE - The relationship in age (oldest to youngest) between geologic units without specific regard to number of years.

RESIDUAL - What is left after a regional field has been removed, as in gravity or magnetic analysis. See RESIDUALIZE.

GLOSSARY OF TERMS (Cont.)

RESIDUALIZE - The process of separating a graphically depicted curve or a surface into its low-frequency parts (called the regional) and its high-frequency parts (called the residual). Residualizing is an attempt to sort out of the total field those anomalies which result from local structure; that is, to fine local anomalies by subtracting gross (regional) effects.

ROCK UNITS - Distinct rock masses with different characteristics (e.g., igneous, metamorphic, sedimentary).

S-WAVE - See SHEAR WAVE.

SAND - Soil passing through No. 4(4.75 mm) sieve and retained on No. 200 (0.075 mm) sieve

SAND DUNE - A low ridge or hill consisting of loose sand deposited by the wind, found in various desert and coastal regions and generally where there is abundant surface sand.

SEISMIC - Having to do with elastic waves. Energy may be transmitted through the body of an elastic solid as P-waves (compressional waves) or S-waves(shear waves).

SEISMIC REFRACTION DATA: deep/shallow - Data derived from a type of seismic shooting based on the measurement of seismic energy as a function of time after the shot and of distance from the shot, by determining the arrival times of seismic waves which have travelled nearly parallel to the bedding in high-velocity layers, in order to map the depth to such layers.

SEISMOGRAM - A seismic record.

SEISMOMETER - See GEOPHONE.

SHEAR WAVE - A body wave in which the particle motion is perpendicular to the direction of propagation. Also called S-Wave or transverse wave.

SHEET FLOW - A process in which storm-borne water spreads as a thin, continuous veneer (sheet) over a large area.

SHEET SAND - A blanket deposit of sand which accumulates in shallow depressions or against rock outcrops, but does not have characteristic dune form.

SHOT - Any source of seismic energy; e.g., the detonation of an explosive.

GLOSSARY OF TERMS (Cont.)

SHOT POINT - The location of any source of seismic energy; e.g., the location where an explosive charge is detonated in one hole or in a pattern of holes to generate seismic energy. Abbreviated SP.

SILT AND CLAY - Fine-grained soil passing through No. 200 (0.075 mm) sieve.

SITE - Location of some specific activity or reference point. The term should always be modified to a precise meaning or be clearly understood from the context of the discussion.

SPECIFIC GRAVITY - The ratio of the weight in air of a given volume of soil solids at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature.

SPLIT SPOON SAMPLE - A disturbed sample obtained with a split spoon sampler with an outside diameter of 2.0 inches (5.1 cm). The sample consists of a split barrel which is driven into the soil using a drop-hammer.

SPREAD - The layout of geophone groups from which data from a single shot are recorded simultaneously. Spreads containing twenty-four geophones have been used in Fugro's seismic refraction surveys.

STREAM CHANNEL DEPOSITS - Materials (clay, silt, sand, gravel, cobbles, boulders) which have been deposited in a stream channel.

STREAM TERRACE DEPOSITS - Stream channel deposits no longer part of an active stream system, generally loose, moderately well graded sand and gravel.

SURFICIAL DEPOSIT - Unconsolidated residual and alluvial deposits occurring on or near the earth's surface.

TRANSITORY - A poorly defined, shallow ephemeral stream across an alluvial fan surface, the position of which is temporary and tends to shift frequently.

UNCONFINED COMPRESSION - A type of test to measure the compressive strength of an undisturbed soil sample.

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) - A system which determines soil classification on the basis of grain-size distribution and Atterberg Limits. (See page A-17).

GLOSSARY OF TERMS (Cont.)

VALLEY SEISMIC REFRACTION SURVEY - Deep seismic refraction measurements made near the middle of a valley to determine seismic wave propagation velocities and thickness of basin fill.

VELOCITY - Refers to the propagation rate of a seismic wave without implying any direction. Velocity is a property of the medium and not a vector quantity when used in this sense.

VELOCITY LAYER - A layer of rock or soil with a homogenous seismic velocity.

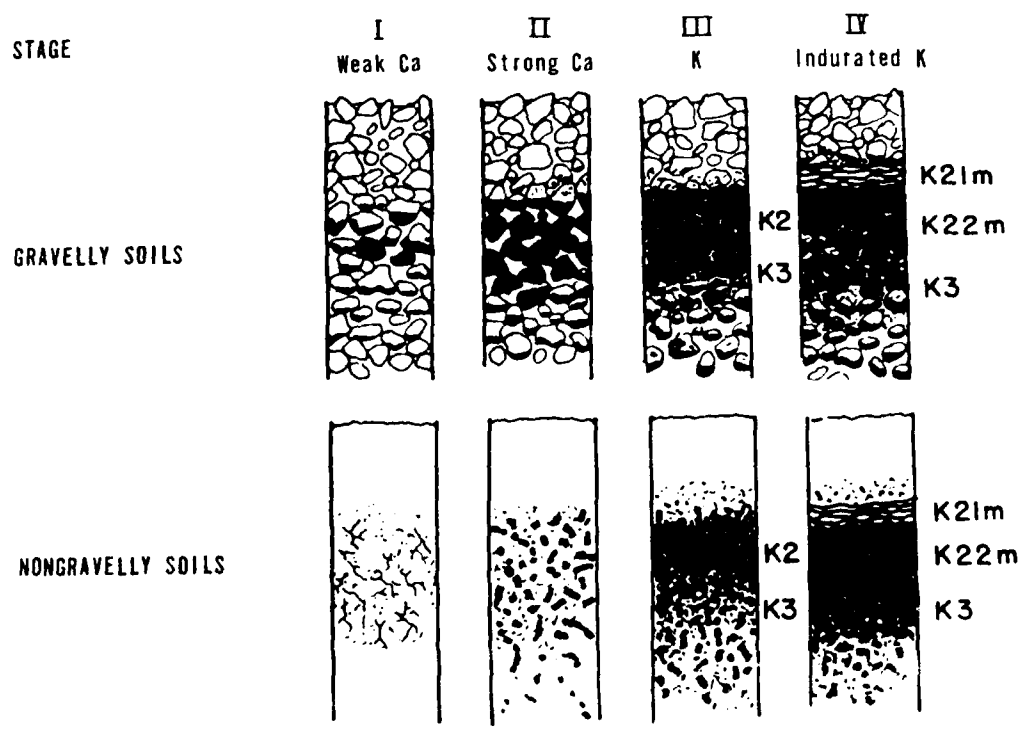
VELOCITY PROFILE - A cross-section showing the distribution of material seismic velocities as a function of depth and its configuration.

WASH SAMPLE - A sample obtained by screening the returned drilling fluid during rotary wash drilling to obtain lithologic information between samples.

Definitions were derived in part from Webster's New Collegiate Dictionary (1972 edition), Glossary of Geology (American Geological Institute, 1972), Encyclopedic Dictionary of Exploration Geophysics (Sheriff, 1973), and 1976 Annual Book Book of ASTM Standards.

DIAGNOSTIC CARBONATE MORPHOLOGY

STAGE	GRAVELLY SOILS	NONGRAVELLY SOILS
I	Thin, discontinuous pebble coatings	Few filaments or faint coatings
II	Continuous pebble coatings, some interpebble fillings	Few to abundant nodules, flakes, filaments
III	Many interpebble fillings	Many nodules and internodular fillings
IV	Laminar horizon overlying plugged horizon	Laminar horizon overlying plugged horizon



Stages of development of a caliche profile with time. Stage I represents incipient carbonate accumulation, followed by continuous build-up of carbonate until, in Stage IV, the soil is completely plugged.

SUMMARY OF CALICHE DEVELOPMENT

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE A-1

Reference: Gile, L H Peterson, F F , and Grossman, R B., 1965. The K horizon, A master horizon of carbonate accumulation: Soil Science, v. 99, p 74-82

NON-ROCK UNITS

(1) AREI SYMBOLS	MX (2) GEOLOGIC UNITS	
Au, Ast	Au	Non-rock Deposits (undifferentiated); fine- to coarse-grained materials deposited by alluvial, fluvial, eolian, lacustrine, gravity or glacial processes.
Aal	A1	Fluvial Deposits; predominantly composed of poorly- to well-graded sand and gravel with lesser amounts of silt- and boulder-sized material. The unit predominantly consists of recent water-laid deposits occupying present drainages and flood plains.
		- Older Fluvial Deposits (A1o) are generally thicker, more extensive units deposited in ancestral fluvial systems.
		- Alluvial Outwash Deposits (A1w) consist of mixed, geomorphically nondescript alluvial and fluvial deposits covering large, relatively flat, river and playa basins.
At	A2	Terrace Deposits; predominantly composed of moderately to well graded, clay- to gravel-sized material. Principally elevated terraces bordering modern streams (A2s) and lakes playas (A2l).
	A3	Eolian Deposits; predominantly composed of poorly graded sand-sized material deposited by wind action. Deposits may consist of mixed sand, silt, and clay (A3u), or be differentiated on the basis of predominant grain size and landform.
		A3s d - Predominantly fine sand-sized material deposited in sheets (A3s) or dunes (A3d).
		A3l - Loess composed predominantly of silt-sized material with lesser amounts of clay and fine sand.
		A3f - Predominantly clay-sized material with lesser amounts of silt and fine sand.
	A4	Lacustrine, Estuarine, and Playa Deposits; predominantly composed of poorly graded clay, silt, and fine sand deposited in bodies of standing water. Older lacustrine, estuarine, and playa deposits (A4o) are thicker, more extensive units occupying ancestral lake basins
Aaf	A5	Alluvial Fan Deposits; predominantly composed of well graded sand and gravel with varying amounts of silt-, cobble-, and boulder-sized material. Deposited principally by distributary channels adjacent to mountain fronts. Relative ages are indicated by o - older, i - intermediate, or y - younger
	A6	Pediment, Pediment Deposits, and Areas of Shallow Rock; planated bedrock shelf or near surface rock generally overlain by a thin mantle of sand- to boulder-sized residual or alluvial material.
	A7	Colluvial Deposits; predominantly composed of moderately- to well-graded sand and gravel with varying amounts of silt-, cobble-, and boulder-sized material. Deposited locally by gravity and water adjacent to steep gradients.

(1) AREI SYMBOLS	MX GEOLOGIC UNITS
gr	
Vu	
Vb	
Su	
Qtz Psa, Pm, Ph, Cau, Ls, Py, Par	
Qtz, gn	

NOTES (1) AREI symbols were developed for use in the Aggregate Resources Evaluation Investigation (See Section 5.1 and Drawings 5.1A through 5.1C)

(2) MX Geologic units were used for Methodology, Screening, and Characterization studies.

(1) AREI SYMBOLS	MX (2) GEOLOGIC UNITS	

ROCK UNITS

Shown in regions where rock is exposed; the areally predominant (greater than 70 percent) rock type is indicated. In those areas where two rock types occur the predominant rock type is shown followed by the subordinate rock type (e.g. S2MP I4T).

	I	IGNEOUS (UNDIFFERENTIATED). Rocks formed by solidification of a molten or partially molten mass.
gr	I1	Intrusive – Typically crystalline, formed by the solidification of molten material below the surface (e.g., granite, syenite, diorite).
Vu	I2	Extrusive (undifferentiated). Formed by solidification of molten material at or near the surface.
Vb	I3	Extrusive (flows). Extrusive rocks formed by solidification of lava (e.g. basalt, dacite) I3b denotes young basaltic flows which may be interbedded with basin-fill materials.
	I4	Extrusive (volcaniclastic). Formed by accumulation, welding and or cementation of deposits of volcanic ejecta (e.g. tuff, agglomerate, lapilli).
Su	S	SEDIMENTARY (UNDIFFERENTIATED). Coarse- to fine-grained materials that exhibit some degree of cementation and were deposited by water, wind, gravity, or evaporation.
Qtz Psa, Pm, Ph, Cau, Ls, Py, Par	S1	Sandstone. Composed predominantly of sand-sized particles.
	S2	Limestone and Dolomite. Composed predominantly of carbonate material.
	S3	Shale. Composed predominantly of clay- and silt-sized particles (e.g. shale, siltstone, mudstone).
	S4	Evaporites. Sediments deposited from solution as a result of evaporation (e.g. gypsum, anhydrite, halite).
	S5	Clastics. Undifferentiated deposits composed of silt- to boulder-sized material. May be angular to rounded.
Qtz, gn	M	METAMORPHIC (UNDIFFERENTIATED). Rocks formed through alteration of igneous or sedimentary rock material by pressure, heat, or chemical changes below the weathered zone (e.g. gneiss, schist, slate, marble, quartzite).
	C	ROCK COMPLEXES. Indicated where no areally predominant (greater than 70 percent) rock type is present.

USEAGE

Modifying letter (s) indicates concentrations of resistant secondary carbonate (caliche), siliceous, ferruginous and or gypsiferous material, e.g. A5ii.

A3s A5y – Mixed non-rock units; most areally extensive unit is listed first.

A5y(A3s) – Parenthetic unit underlies thin veneer of overlying mapped unit.

S5to – Established formations may have a supplemental letter added to distinguish formal designation (e.g. Tertiary Ogallala Fm.)

EXPLANATION OF GEOLOGIC UNITS

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE A-1

UGRO NATIONAL, INC.

Major Divisions		Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights)			Information Required for Describing Soils
1	2	3	4	5			6
Coarse-Grained Soils: More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels: More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the ¼-in. size may be used as equivalent to the No. 4 sieve size) Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			
	Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)			
		GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size. Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			Example: Silty sand, gravelly; about 20% hard, angular gravel particles ½-in. maximum size; rounded and subangular sand grains coarse to fine, about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).
		SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			
	Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (for identification procedures see ML below)			
		SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).			
Fine-Grained Soils: More than half of material is smaller than No. 200 sieve size.	Silts and Clays: Liquid limit less than 50			Identification Procedures on Fraction Smaller than No. 40 Sieve Size			
				Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)	
		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium	
		OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions
	Silts and Clays: Liquid limit greater than 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium	
		CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High	
		OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).
Highly Organic Soils		Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.			

UNIFIED SOIL CLASSIFICATION SYSTEM

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE A-2

UGRO NATIONAL, INC.

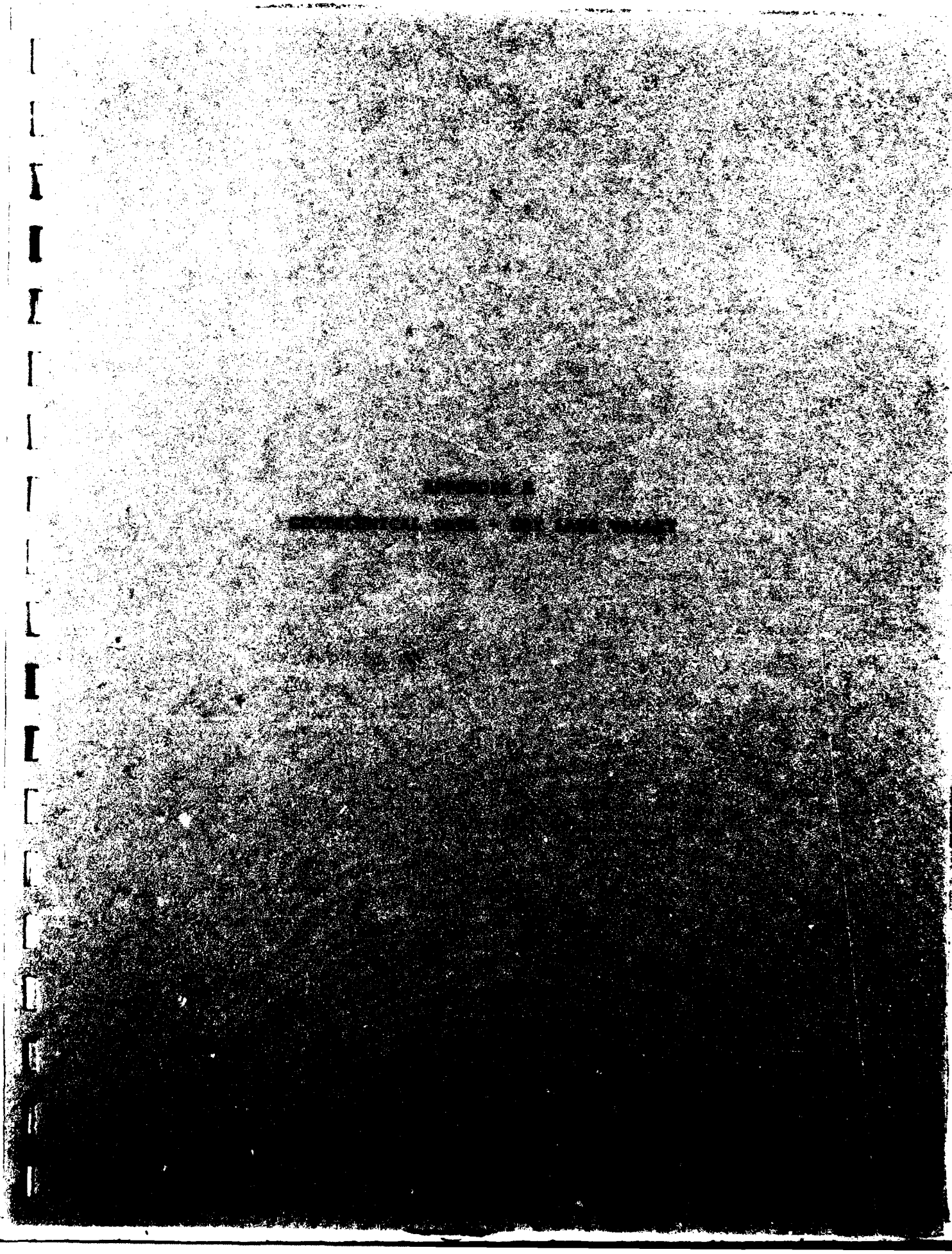
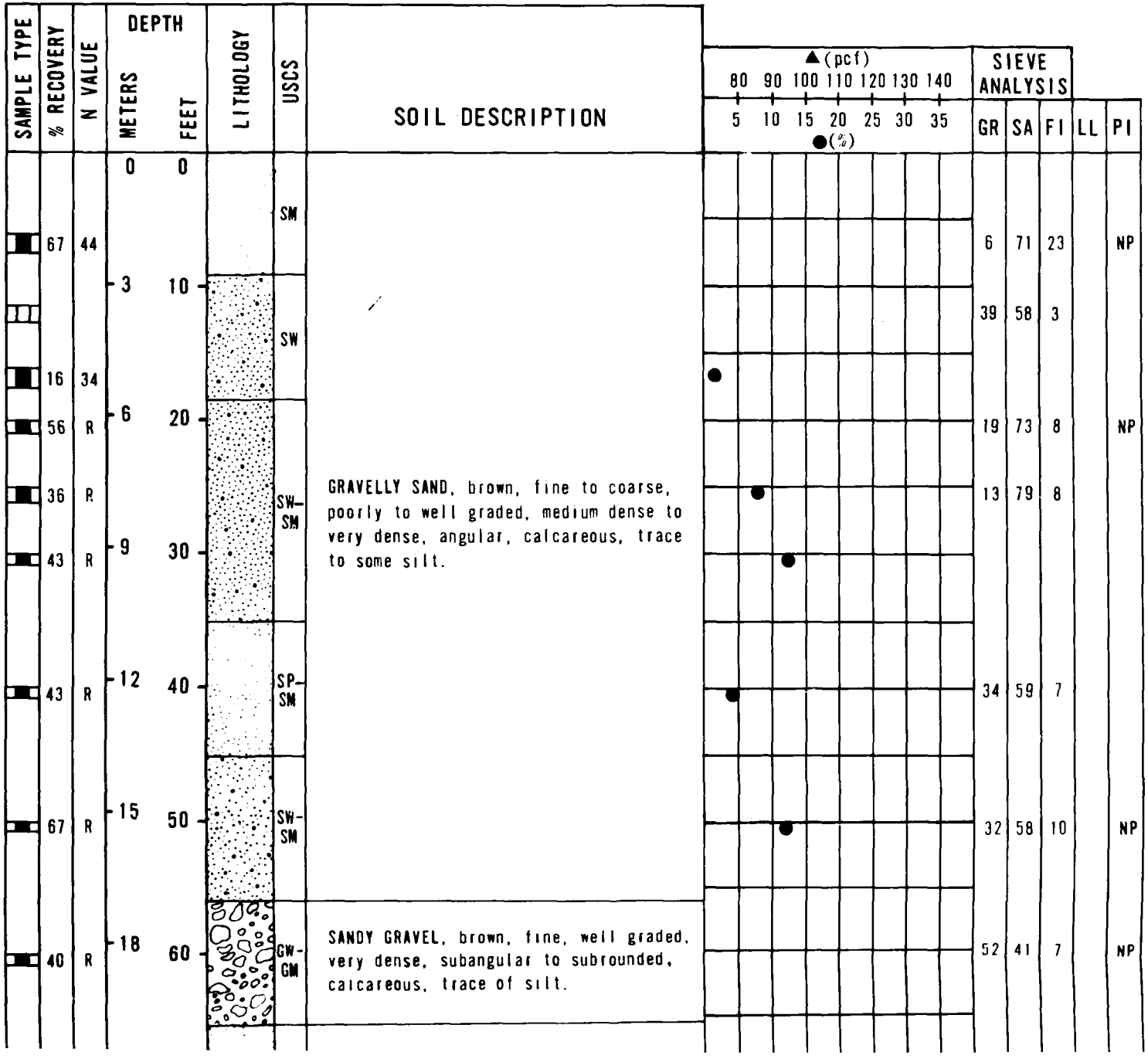
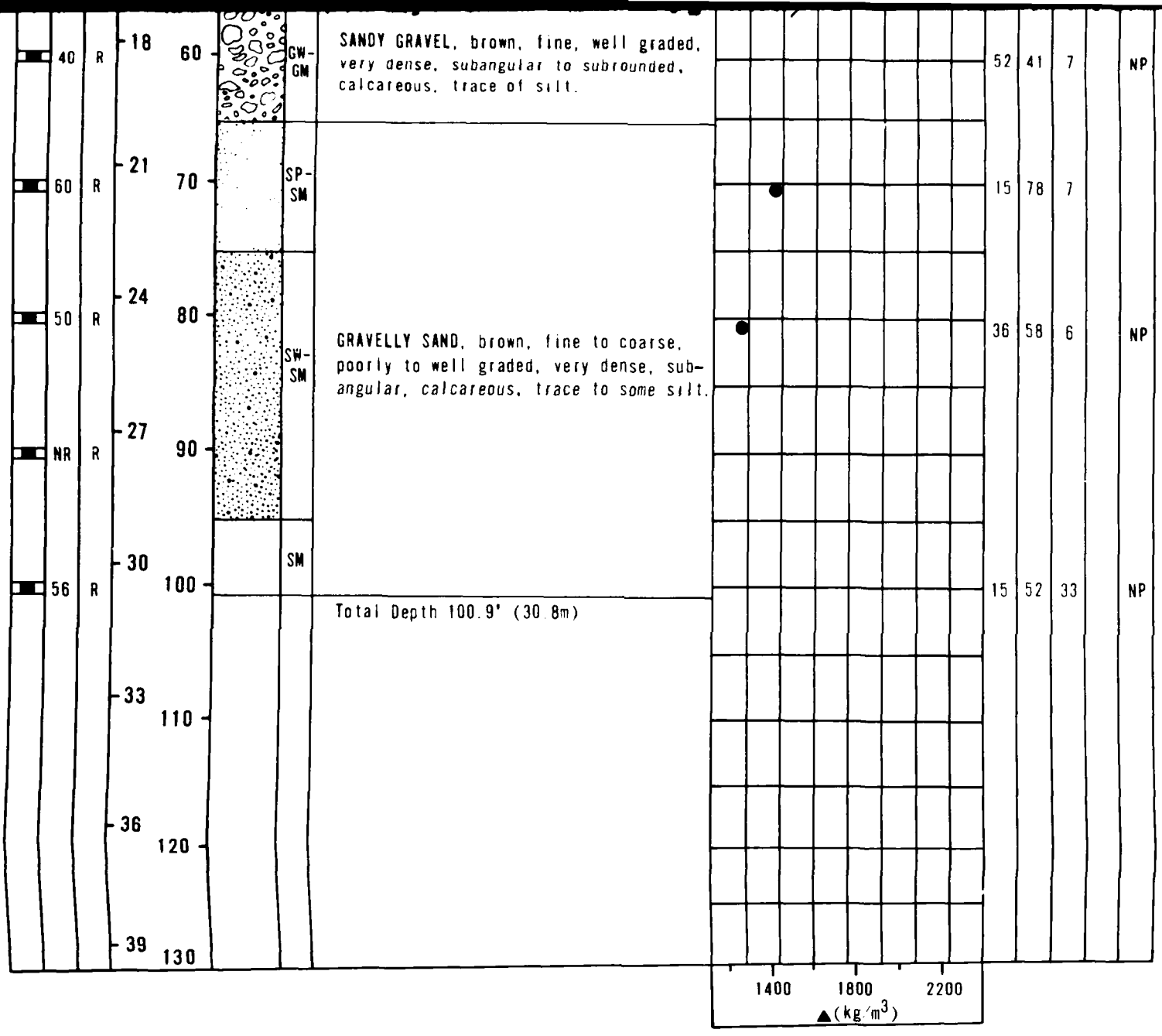


TABLE OF CONTENTS
APPENDIX B

CHECKED BY _____ APPROVED BY _____

FN-TR-26a





FUGRO

DEPARTMENT OF MINERALS AND ENERGY

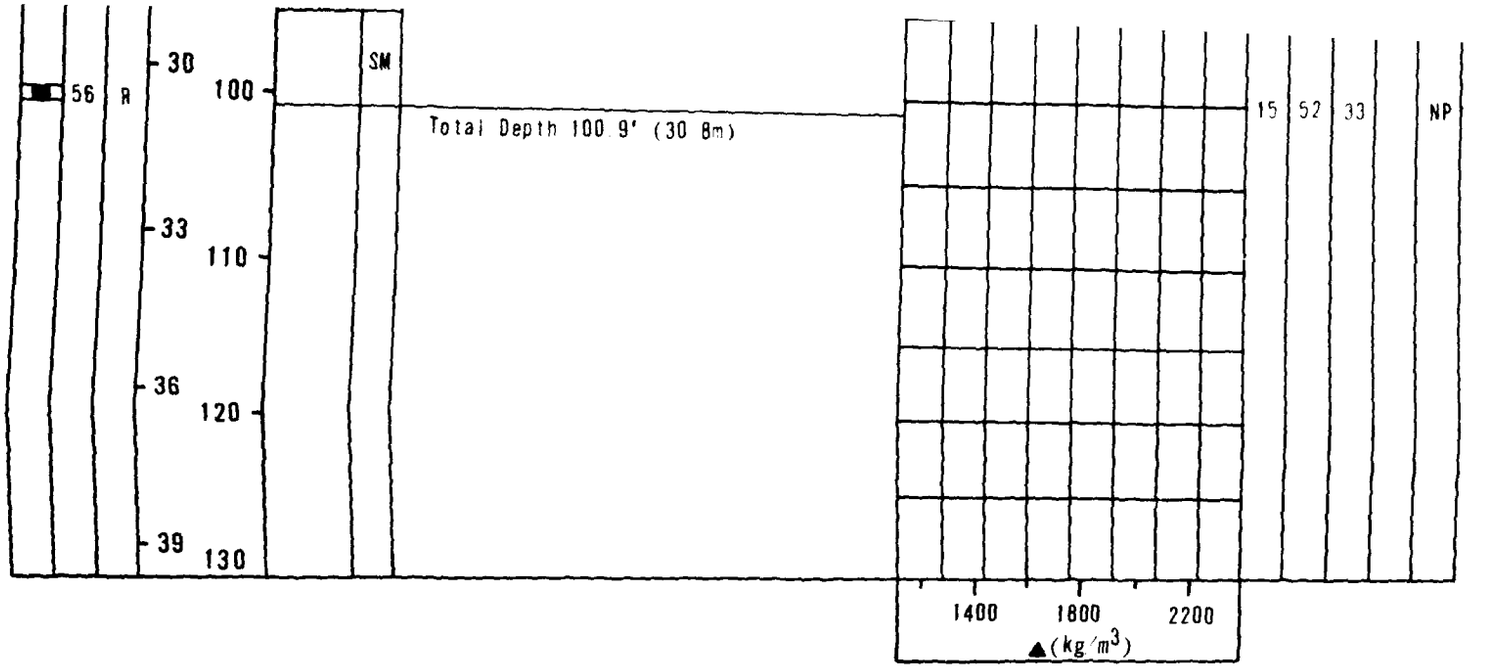
LOT 1 ORY

SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE

BORING DETAILS

ELEVATION	: 5112' (1558m)
DATE DRILLED	: 11JULY 1977
DRILLING METHOD	: ROTARY WASH
HOLE DIAMETER	: 4 7 8'' (124mm)



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 5112' (1558m)
DATE DRILLED	: 11 JULY 1977
DRILLING METHOD	: ROTARY WASH
HOLE DIAMETER	: 4 7 8'' (124mm)
CASING INSTALLED	: 90' (27m)
WATER LEVEL	: Not Encountered

FUGRO NATIONAL, INC.

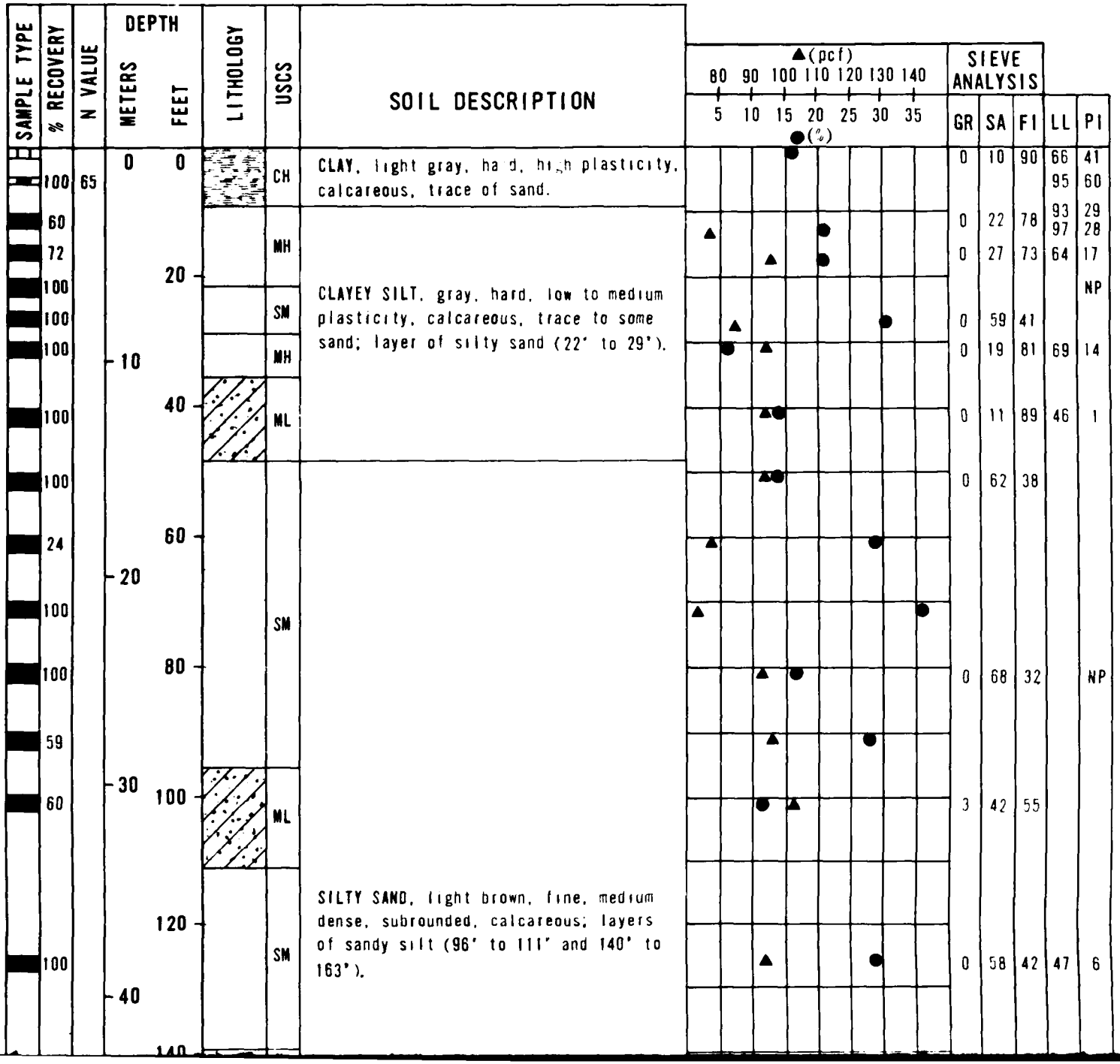
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

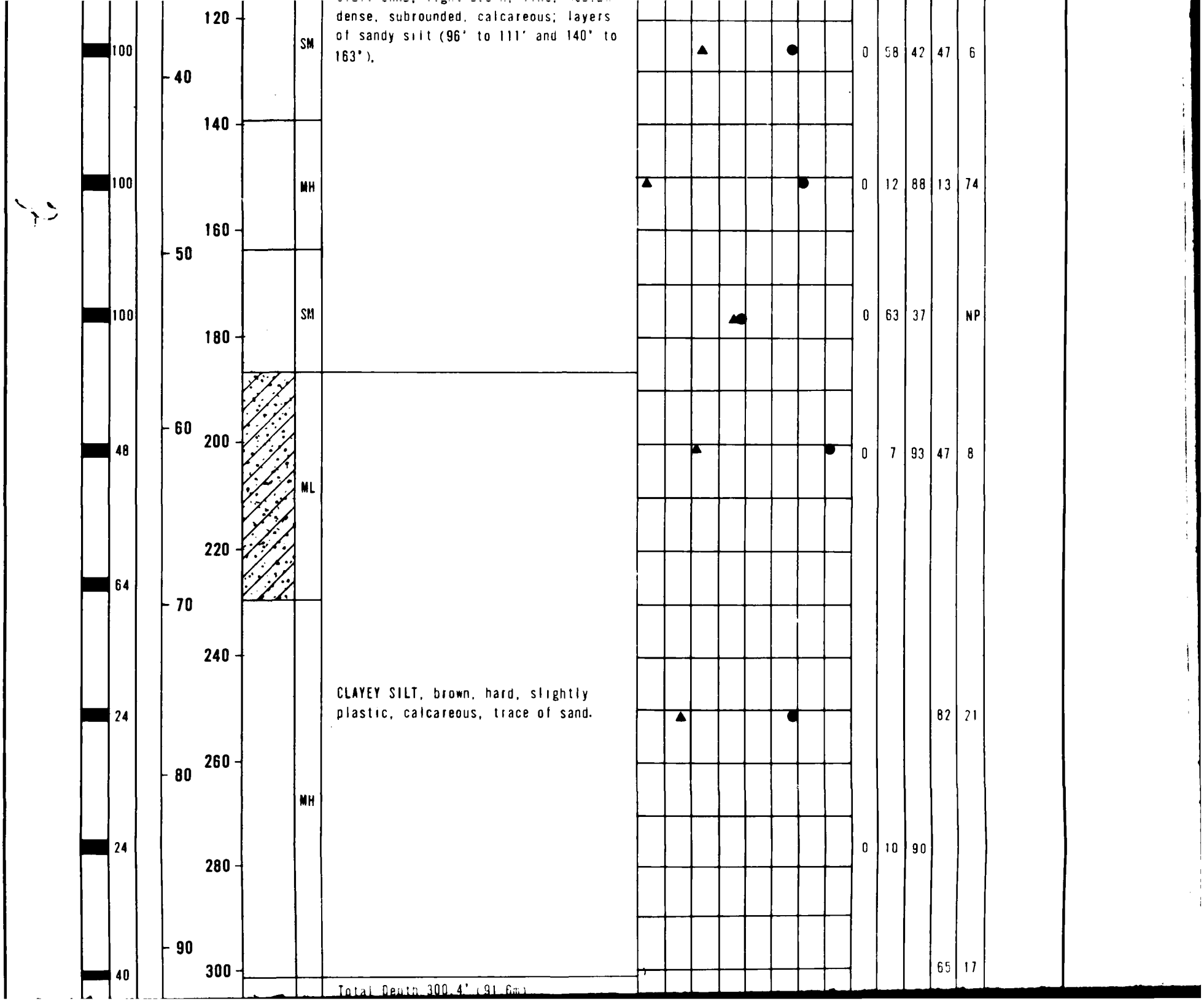
FIGURE B-1

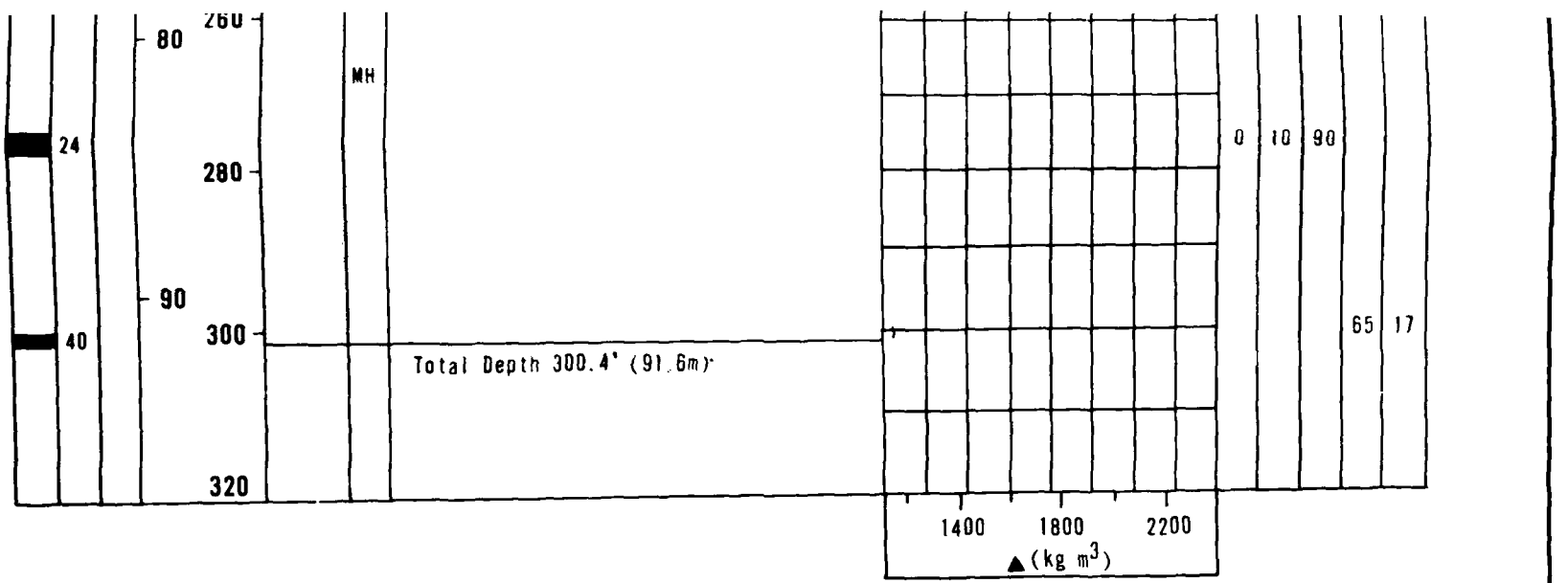
LOG OF BORING DL-B-2
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

CHECKED BY _____ APPROVED BY _____

FN-TR-26a




dense, subrounded, calcareous; layers of sandy silt (96' to 111' and 140' to 163').
CLAYEY SILT, brown, hard, slightly plastic, calcareous, trace of sand.
Total Depth 300.4' (91.6m)
SM
MH
SM
ML
MH
100
100
100
48
64
24
24
40
120
140
160
180
200
220
240
260
280
300
40
50
60
70
80
90
0 98 42 47 6
0 12 88 13 74
0 63 37 NP
0 7 93 47 8
82 21
0 10 90
65 17



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE
- CORE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 4582' (1397m)
DATE DRILLED	: 28 JUNE 1977
DRILLING METHOD	: ROTARY AIR
HOLE DIAMETER	: 4 7 8'' (124mm)
CASING INSTALLED	: 292' (89m)
WATER LEVEL	: Not Encountered

FUGRO NATIONAL, INC.

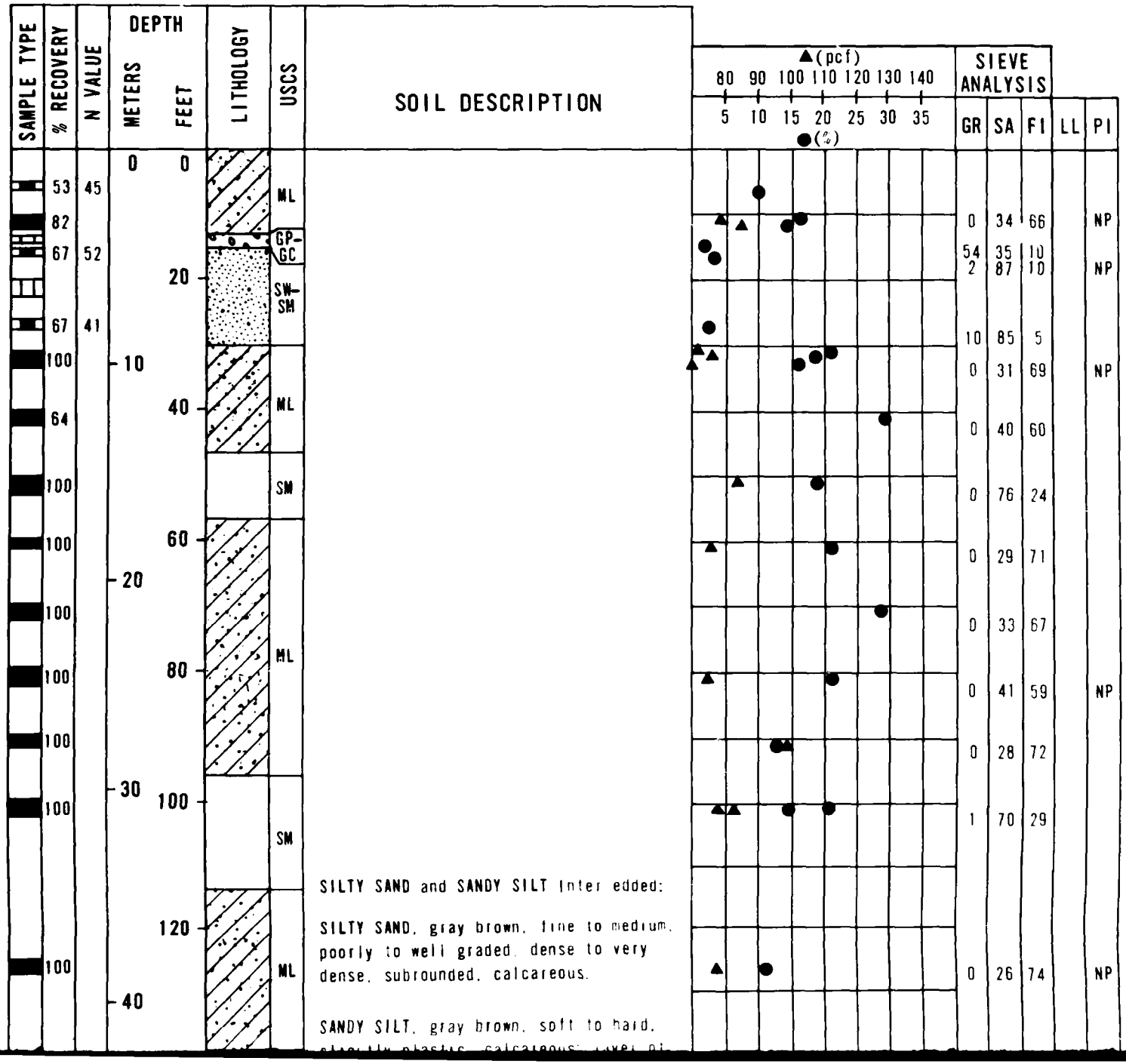
LOG OF BORING DL-B-5
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

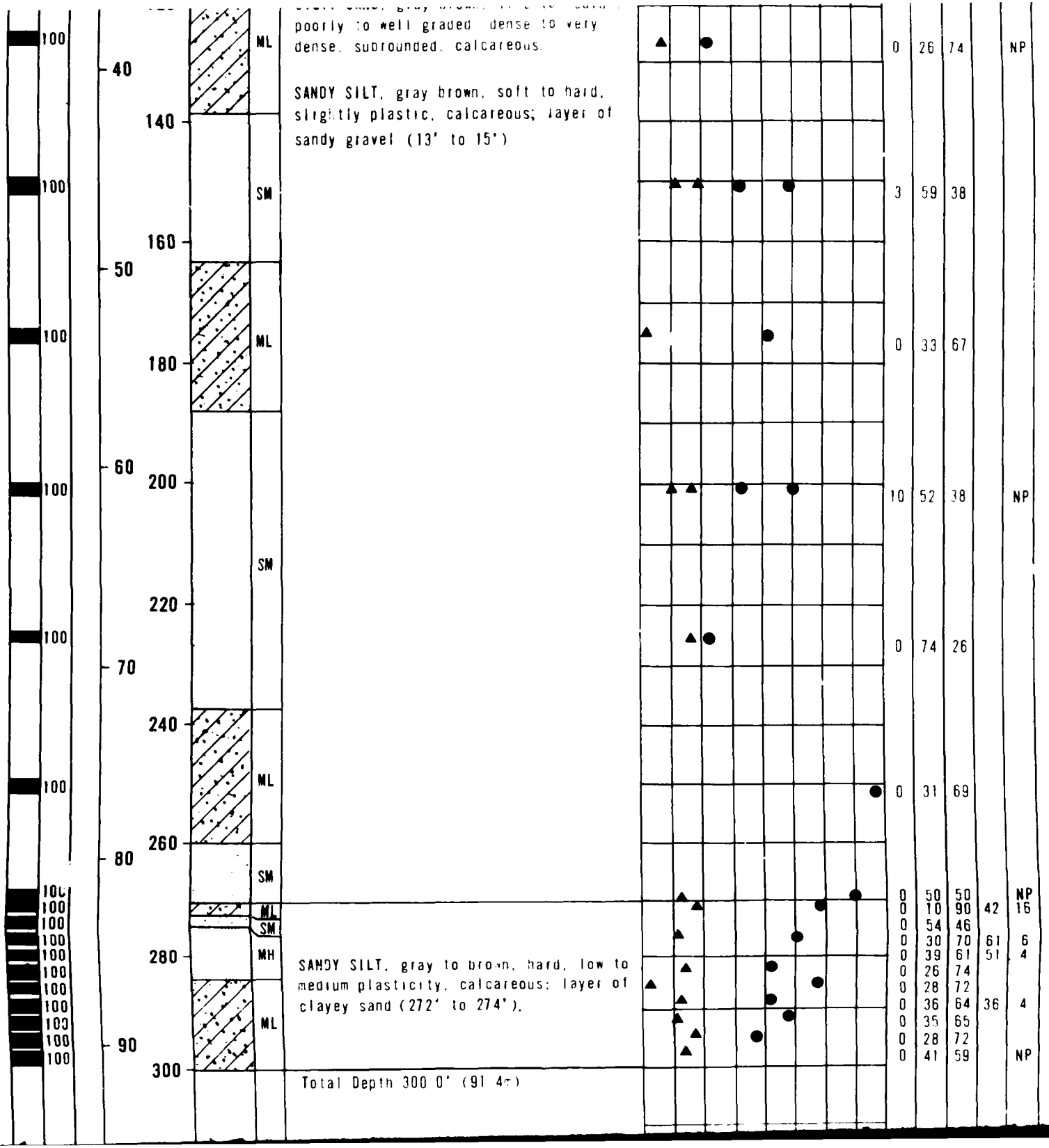
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

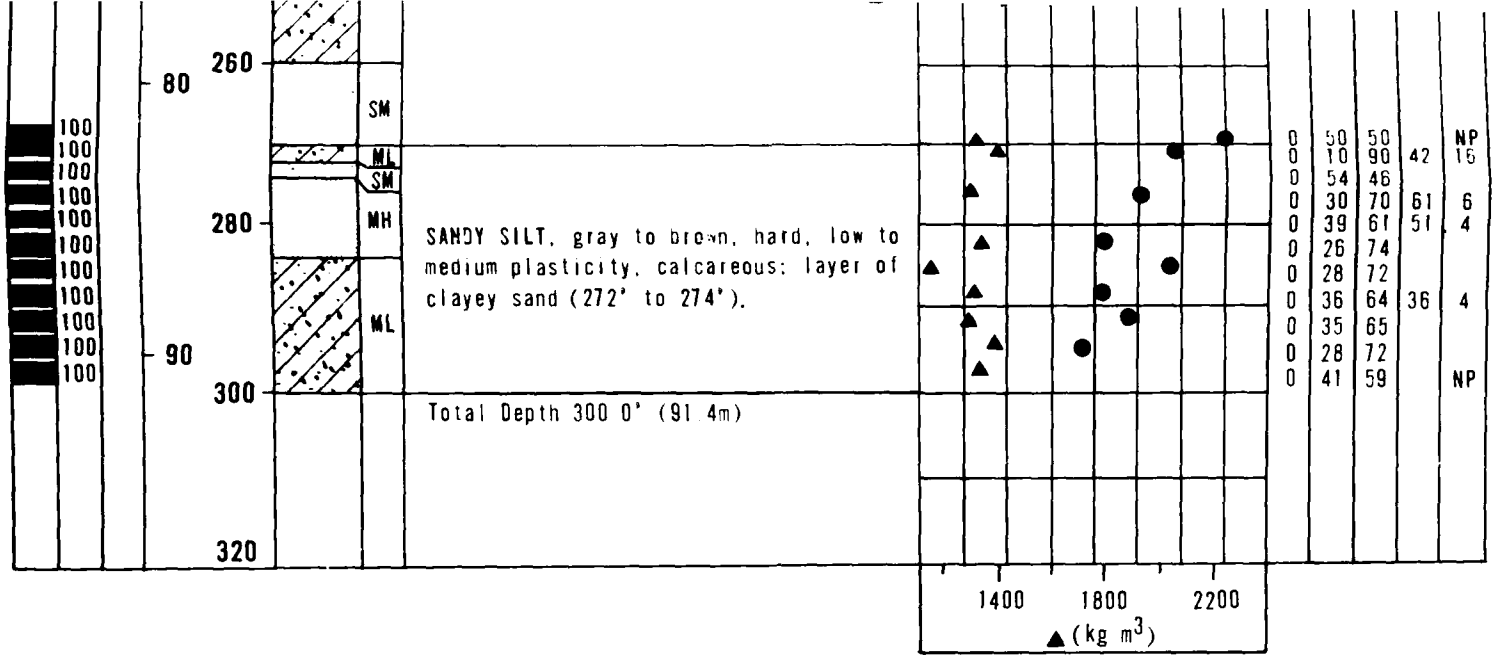
FIGURE B-2

CHECKED BY _____ APPROVED BY _____

FN-TR-26a




poorly to well graded dense to very dense, subrounded, calcareous.
SANDY SILT, gray brown, soft to hard, slightly plastic, calcareous; layer of sandy gravel (13' to 15')
SANDY SILT, gray to brown, hard, low to medium plasticity, calcareous; layer of clayey sand (272' to 274').
Total Depth 300.0' (91.4m)
ML
SM
MH
100
40
50
60
70
80
90
140
160
180
200
220
240
260
280
300
0 26 74 NP
3 59 38
0 33 67
10 52 38 NP
0 74 26
0 31 69
0 50 50 NP
0 10 90 42 16
0 54 46
0 30 70 61 6
0 39 61 51 4
0 26 74
0 28 72
0 36 64 36 4
0 35 65
0 28 72
0 41 59 NP



3

SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE
- CORE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 4655' (1419m)
DATE DRILLED	: 30 JUNE 1977
DRILLING METHOD	: ROTARY AIR WASH
HOLE DIAMETER	: 4 7 8'' (124mm)
CASING INSTALLED	: 296' (90m)
WATER LEVEL	: Not Encountered

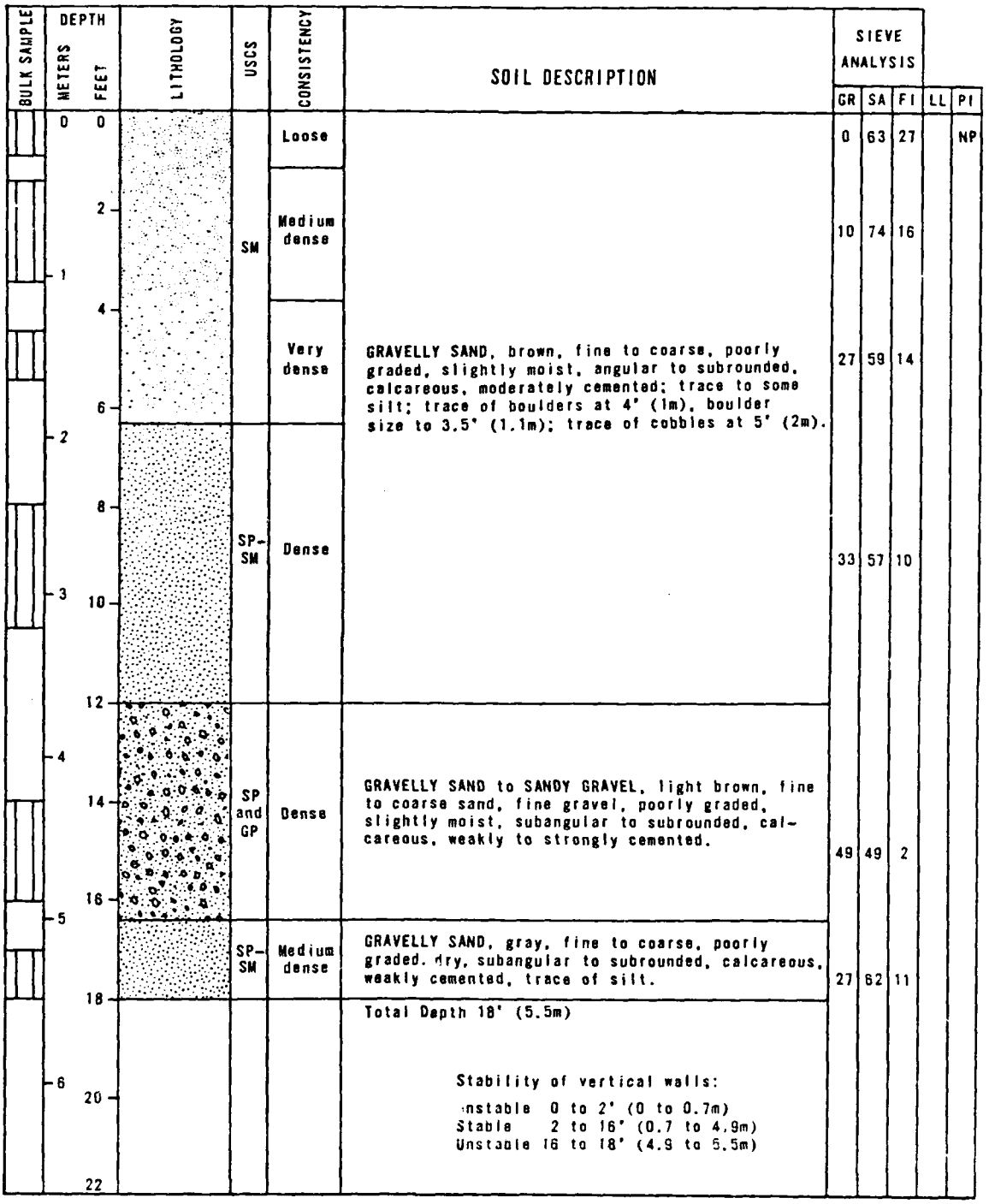
FUGRO NATIONAL, INC.

LOG OF BORING DL-B-12
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE B-3

FN-TR-26e



TRENCH DETAILS

SURFACE ELEVATION : 5112' (1558m)
DATE EXCAVATED : 24 August 1977
SURFACE GEOLOGIC UNIT : A5y
TRENCH LENGTH : 57' (17m)
TRENCH ORIENTATION : N60E

LOGGED BY _____ CHECKED BY _____ APPROVED BY _____

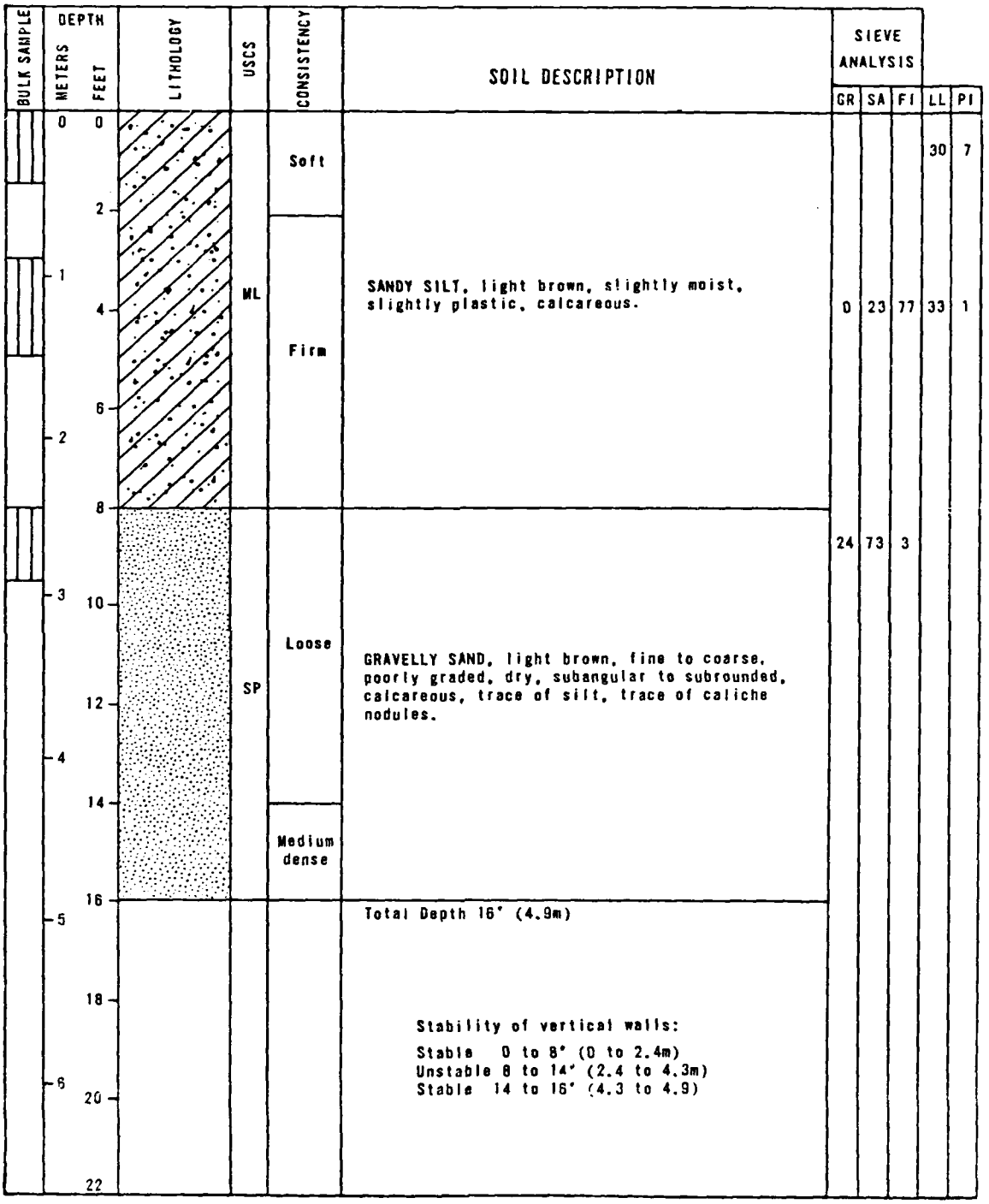
LOG OF TRENCH DL-T-2
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
B-4

UGRO NATIONAL, INC.

FN-TR-26e



TRENCH DETAILS

SURFACE ELEVATION : 4783' (1458m)
DATE EXCAVATED : 24 August 1977
SURFACE GEOLOGIC UNIT : A1
TRENCH LENGTH : 60' (18m)
TRENCH ORIENTATION : N80W

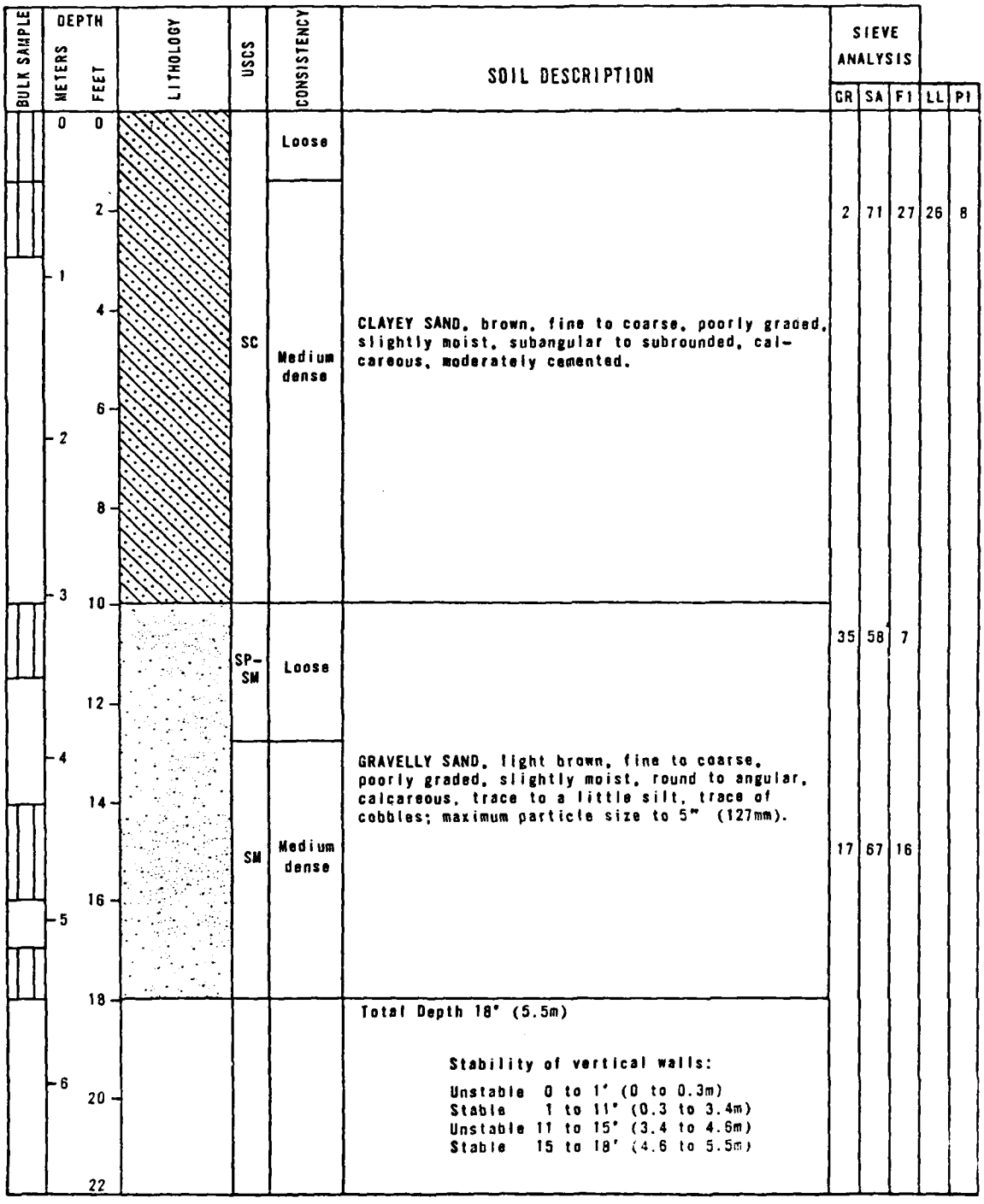
LOG OF TRENCH DL-T-8
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
B-5

FUGRO NATIONAL, INC.

FN-TR-26a



LOGGED BY

CHECKED BY

APPROVED BY

TRENCH DETAILS

SURFACE ELEVATION : 4880' (1487m)
DATE EXCAVATED : 24 August 1977
SURFACE GEOLOGIC UNIT : A5y
TRENCH LENGTH : 58' (18m)
TRENCH ORIENTATION : N10E

LOG OF TRENCH DL-T-9
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
B-6

UGRO NATIONAL, INC.

BORING NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL		PERCENT FINER BY WEIGHT										
				STANDARD SIEVE OPENING							U S STANDARD SIEVE			
				BLDRS.	COBBLES		GRAVEL				SAND			
		FEET	METERS	24"	12"	6"	3"	1½"	3 4"	3 8"	4	10	40	100
DL-B-12	SS-1	5.0- 5.6	1.52- 1.77											
	P-2	10.1- 10.7	3.08- 3.26											
		10.7- 10.9	3.26- 3.32									100	92	7
		10.9- 11.6	3.32- 3.54											
	B-3	13.5- 14.5	4.11- 4.42					100	8	59	46	31	14	1
	SS-4	15.0- 16.0	4.57- 4.88							100	98	91	59	1
	SS-6	26.0- 27.0	7.92- 8.23						10	95	90	80	38	1
	P-7	31.0- 31.7	9.45- 9.66											
		31.7- 32.3	9.66- 9.85											
		32.3- 32.6	9.85- 9.94									100	93	7
		32.6- 33.3	9.94-10.15											
	P-8	40.7- 40.8	12.41-12.44									100	75	6
	P-9	51.3- 51.8	15.64-15.79								100	90	55	3
	P-10	60.7- 60.9	18.50-18.56									100	89	7
	P-11	70.7- 71.3	21.55-21.73											
		71.3- 71.5	21.73-21.79									100	95	8
	P-12	81.3- 81.7	24.78-24.90									100	92	7
	P-13	91.1- 91.3	27.77-27.83									100	99	8
	P-14	100.1-100.7	30.51-30.69											
		101.4-101.9	30.91-31.06								100	99	68	3
	P-15	126.3-126.8	38.50-38.65									100	94	8
	P-16	150.0-150.7	45.72-45.93											
		150.7-151.3	45.93-46.12											
		151.3-151.8	46.12-46.27								100	97	77	4
	P-17	176.4-176.8	53.77-53.89									100	92	7
	P-18	200.1-200.7	60.99-61.17											
		201.3-201.5	61.36-61.42								100	90	50	4
	P-19	225.8-226.0	68.82-68.88									100	96	4
	P-20	251.4-251.6	76.63-76.69									100	99	9
	P-21	269.7-269.9	82.20-82.27									100	99	7
	P-22	270.8-271.2	82.54-82.66									100	99	9
	P-23	274.3-274.5	83.61-83.67								100	96	68	5
	P-24	276.0-276.7	84.12-84.34											
		277.3-277.5	84.52-84.58									100	94	8
	P-25	280.3-280.5	85.44-85.50							100	99	98	87	7
	P-26	283.3-283.8	86.35-86.50									100	98	8
	P-27	286.3-286.8	87.26-87.42								100	99	88	7
	P-28	289.3-289.6	88.18-88.27									100	96	8
	P-29	292.3-292.6	89.09-89.18									100	92	7
	P-30	294.0-294.7	89.61-89.82											
		294.7-295.3	89.82-90.01											
		295.3-295.6	90.01-90.10									100	96	8
	P-31	298.3-298.6	90.92-91.01										100	8

NOTES:

(a) Sample types
- SS - Standard split spoon
- P - Pitcher
- D - Fugro Drive
- B - Bulk

(b) NP - Not Plastic

(c) USCS - Unified Soil Classification System; Table A-I

(d) *Indicates that test has been performed and results are included in this report.

SIEVE NO		PARTICLE SIZE (mm)		ATTERBERG LIMITS (b)			USCS (c)	IN-SITU					COMPACTED			SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION
	SILT OR CLAY							DRY UNIT WEIGHT		MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)					
100	200	.005	.001	LL	PL	PI		(pcf)	(kg m^3)				(pcf)	(kg m^3)						
							ML			10										
						NP	ML													
75	66	37	8				ML	78.5	1257	16	38	1.15								
							ML	83.1	1331	14.1	37	1.03								
11	10						GP-GC			1										
19	10					NP	SW-SM			4										
12	5						SW			3										
							ML	69.8	1118	16	31	1.42								
							ML	72.8	1166	21.1	42	1.36					*			
76	69	20	5			NP	ML	76.8	1230	19	42	1.20								
							ML	84.2	1349	13.8	37	1.00								
65	60	23	8				ML													
34	24						SC	82.8	1326	18	48	1.04								
79	71	20	8			NP	ML	76.7	1229	21	46	1.20								
							ML	75.6	1211	18.9	42	1.23						*		
80	67	25	9				ML													
76	59	31	10			NP	ML	75.0	1201	21	47	1.25								
84	72	19	6				ML	99.5	1594	14	54	.69								
							SC	81.3	1302	14.7	37	1.07								
39	29						SC	78.6	1259	20	48	1.14								
84	74	10	3			NP	ML	78.3	1254	12	27	1.15								
							SC	89.2	1429	16.6	50	.89								
							SC	93.2	1493	23.7	79	.81						*		
45	38						SC	80.9	1296	25	62	1.08								
76	67	15	4				ML	73.1	1171	21	44	1.30								
							SM	87.7	1405	16.2	48	.92								
41	38					NP	SM	88.5	1418	25	75	.90								
43	26	6	2				SM	87.5	1402	12	35	.93								
91	69	14	6				ML													
79	50					NP	SM	82.7	1325	35	91	1.04								
95	90			42	26	16	CL	87.9	1408	29	86	.92								
52	46						SM													
							MH	81.2	1301	24.9	62	1.08								
81	70	31	8	61	45	16	MH													
72	61			51	46	5	MH													
85	74	17	4				MH	84.2	1349	20	55	1.00								
77	72						ML	73.7	1181	29	60	1.29								
86	64			36	31	4	ML	82.2	1317	20	53	1.05								
77	65						ML	80.9	1296	24	60	1.08								
							ML	87.8	1406	18.2	54	.92								
							ML	76.6	1227	36.8	83	1.20						*		
85	72	38	10				ML													
83	59	14	5				ML	82.7	1325	22	57	1.04								

SUMMARY OF LABORATORY T
BORING DL-8-1
DRY LAKE VALLEY, NEVADA, G

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE

FUGRO NATIO

IN-SITU				COMPACTED										
	MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY (pcf)	MAXIMUM DRY DENSITY (kg m³)	OPTIMUM MOISTURE (%)	SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	RELATIVE DENSITY
	10											*	
67	16	38	1.15										
31	14.1	3[illegible]	1.03										
	1												
	4												
	3												
18	16	31	1.42										
06	21.1	42	1.36					*					
30	19	42	1.20										
49	13.8	37	1.00										
16	16	48	1.04										
09	21	46	1.20										
11	18.9	42	1.23						*				
61	21	47	1.25										
594	14	54	.69										
502	14.7	37	1.07										
259	20	48	1.14										
154	12	27	1.15										
429	16.6	50	.89										
493	23.7	79	.81						*				
96	25	62	1.08										
171	21	44	1.30										
405	16.2	48	.92										
418	25	75	.90										
402	12	35	.93										
325	35	91	1.04										
408	29	86	.92										
331	24.3	62	1.08										
349	20	55	1.00										
181	29	60	1.29										
317	20	53	1.05										
296	24	60	1.08										
406	18.2	54	.92										
227	36.8	83	1.20						*			*	
325	22	57	1.04										

SUMMARY OF LABORATORY TEST RESULTS
BORING DL-B-12
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE B-1

FUGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	UNCONFINED COMP. STRENGTH		DRY DENSITY		MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	HEIGHT / DIAMETER
		FEET	METERS		ksf	kN/m²	pcf	kg/m³			
DL-B-5	P-3	15.3-15.9	4.66-4.85	MH	10.8	517	70.5	1129	40.5	78.7	2.0
	P-5	26.7-27.3	8.14-8.32	SM	7.2	345	73.0	1169	33.0	68.1	2.4
DL-B-8	P-2	10.9-11.6	2.32-3.54	ML	2.4	115	82.5	1281	14.1	36.6	2.4
	P-16	118.0-118.7	35.97-36.18	ML	4.2	201	101.2	1621	16.9	68.6	2.4
	P-19	180.6-181.2	55.05-55.23	ML	2.1	101	85.0	1320	30.7	84.4	2.4
DL-B-12	P-11	70.7-71.3	21.55-21.73	ML	4.6	221	75.6	1211	18.9	41.6	2.4
	P-16	150.7-151.3	45.93-46.12	SM	15.1	723	93.2	1493	23.7	79.3	2.2
	P-30	294.7-295.3	89.82-90.01	ML	9.5	453	76.6	1227	36.8	82.9	2.2
DL-B-18	P-1	5.0-5.7	1.52-8.69	SM	3.2	155	95.3	1527	10.3	36.0	2.4
	P-8	50.0-50.7	15.24-15.45	ML	6.7	321	84.7	1357	20.9	57.0	2.4
DL-B-19	P-2	10.0-10.7	3.05-3.26	MH	8.2	393	87.1	1395	22.4	64.7	2.4
	P-10	71.8-72.4	21.88-22.07	ML	6.8	326	74.7	1197	36.4	78.3	2.4

SUMMARY OF UNCONFINED COMPRESSION TEST RESULTS

DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE B-2

FUGRO NATIONAL, INC.

FN-TR-260

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	TYPE OF TEST	DRY DENSITY		MOISTURE CONTENT	CONFINING PRESSURE (σ_3)		MAXIMUM DEVIATOR STRESS ($\sigma_1-\sigma_3$)		STRAIN RATE	BACK PRESSURE	
		FEET	METERS			pcf	kg/m^3	(%)	ksf	kN/m^2	ksf	kN/m^2	(% min)	ksf	kN/m^2
DL-B-8	P-8	51.0-51.6	15.54-15.73	SP	CD	95.7	1533	5.3	9.8	469	35.1	1680	.11	0	0
	P-8	50.0-50.7	15.24-15.45	SP	CD	102.6	1643	7.0	4.9	235	17.1	819	.11	0	0
	P-17	140.0-140.7	42.67-42.89	MH	CD	80.6	1291	34.1	14.0	670	25.8	1235	.10	0	0
	P-19	180.0-180.6	54.86-55.05	ML	CD	82.6	1323	27.8	27.8	1331	53.7	2571	.11	0	0
DL-B-12	P-7	32.6-33.3	9.94-10.15	ML	CD	84.2	1349	13.8	7.5	359	29.5	1412	.10	0	0
	P-7	31.7-32.3	9.66-9.85	ML	CD	74.5	1193	17.4	3.7	177	18.8	900	.10	0	0
DL-B-18	P-4	20.0-20.6	6.10-6.28	SP	CD	98.1	1571	10.3	2.0	96	11.3	541	.10	0	0
	P-4	20.6-21.2	6.28-6.46	SP	CD	98.1	1571	6.2	3.5	168	14.7	704	.09	0	0
DL-B-19	P-6	31.3-31.9	9.54-9.72	SM	CD	78.1	1251	22.5	6.6	316	40.2	1925	.09	0	0

SUMMARY OF TRIAXIAL SHEAR TEST RESULTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE B-3

FUGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	NORMAL STRESS		MAXIMUM SHEAR STRENGTH	
		FEET	METERS		ksf	kN/m^2	ksf	kN/m^2
DL-B-8	P-14	90.0-90.6	27.43-27.61	SM	9.0	431	6.4	306
DL-B-13	P-10	80.0-80.7	24.38-24.60	SW-SM	8.5	407	5.7	273
	P-17	225.0-225.7	68.58-68.79	SP-SC	12.0	575	8.2	393
DL-B-18	P-6	30.0-30.7	9.14-9.36	SM	3.0	144	3.7	177

SUMMARY OF DIRECT SHEAR TEST RESULTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE B-4

UGRO NATIONAL, INC.

FN-TR-28e

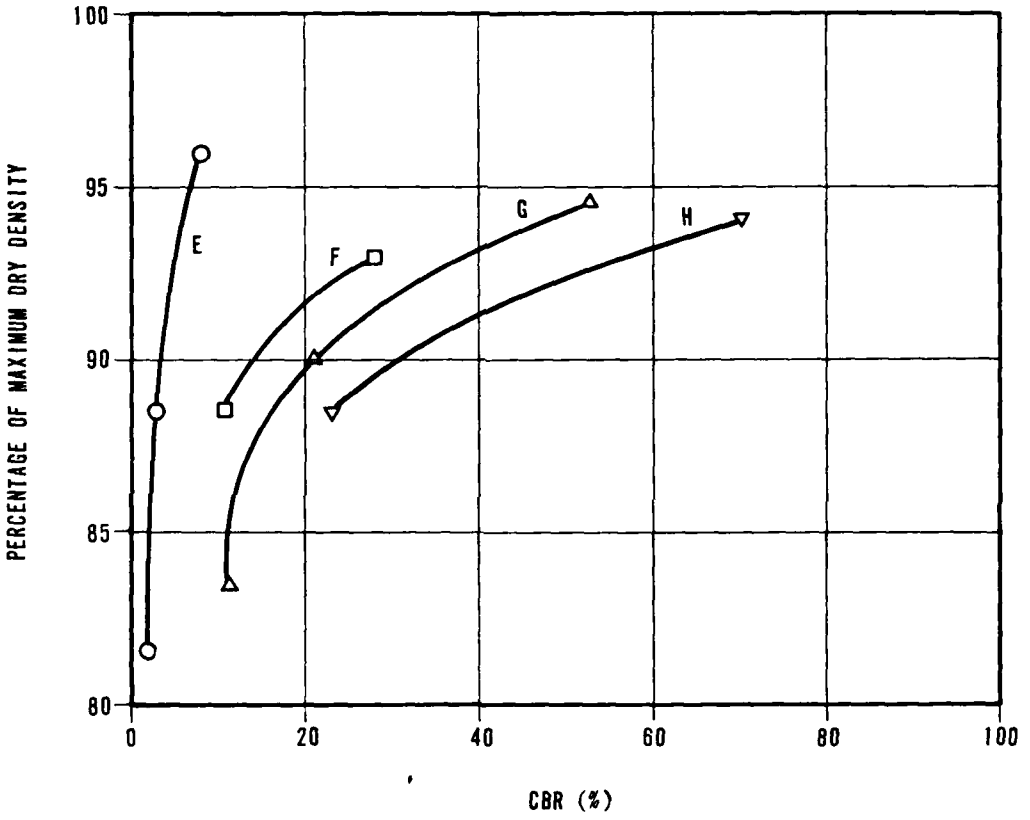
COMPOSITE SAMPLE NUMBER	SOIL TYPE	PERCENT PASSING #200	ATTERBERG LIMITS		SPECIFIC GRAVITY	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)	COMPACTED DRY DENSITY		COMPACTED MOISTURE (%)	PERCENT OF MAXIMUM DRY DENSITY	CBR (%)
			LL	PI		pcf	kg/m³		pcf	kg/m³			
E	ML	68	24	2	2.59	110.8	1775	16.5	106.2	1701	14.2	95.8	8
									98.2	1573	15.0	88.6	3
									90.3	1446	14.7	81.5	2
F	SM	16			2.57	128.5	2058	8.5	119.4	1913	8.6	92.9	28
									113.9	1825	8.8	88.6	11
G	SM	41			2.55	108.5	1738	18.0	102.7	1645	18.1	94.7	53
									97.7	1565	18.4	90.0	21
									90.6	1451	18.4	83.5	11
H	SM	16			2.60	124.0	1986	10.0	116.7	1869	9.3	94.1	70
									109.8	1759	9.5	88.6	23

CALIFORNIA BEARING RATIO
(CBR) TEST RESULTS
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE B-5

FUGRO NATIONAL, INC.



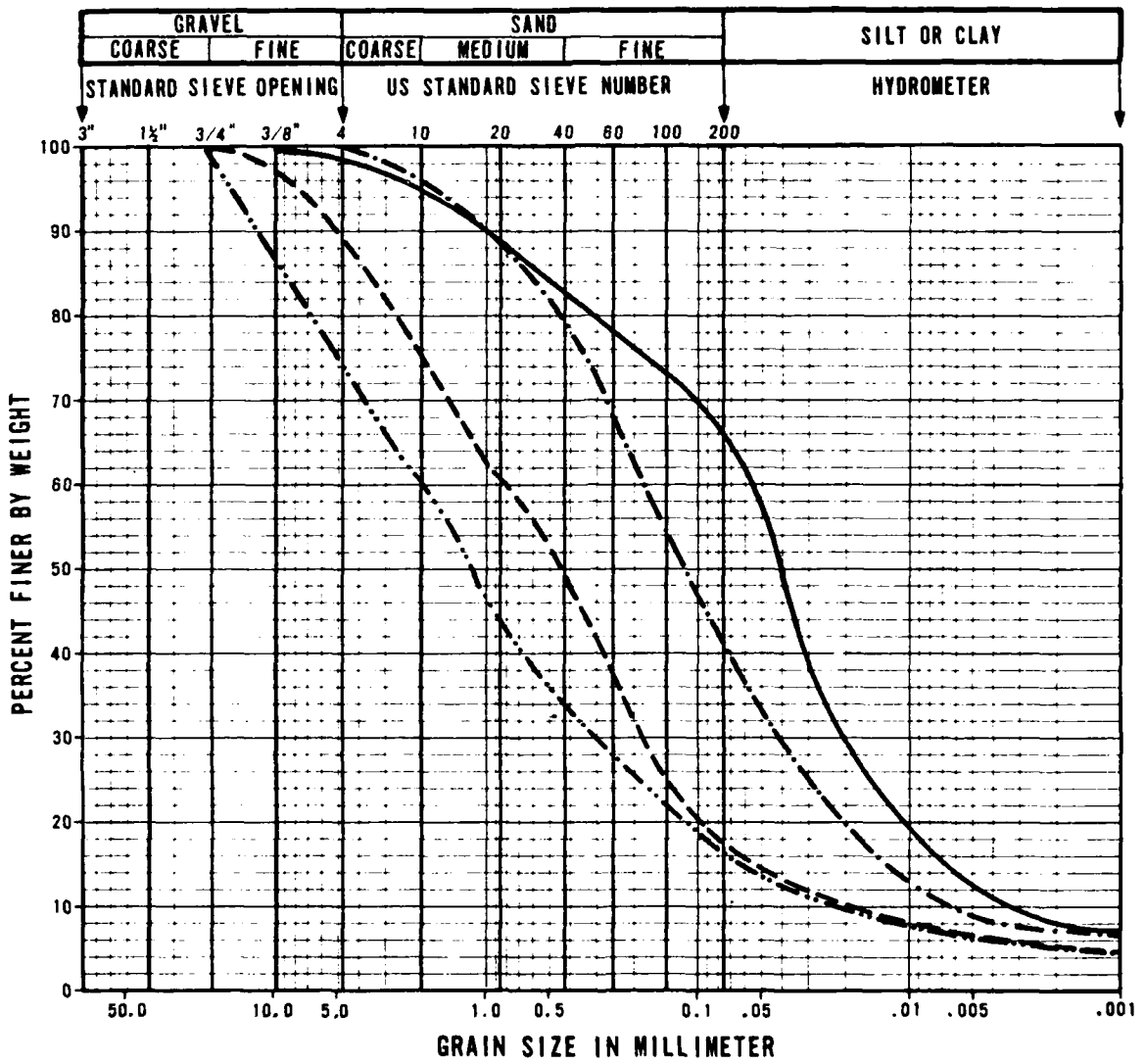
SYMBOL	COMPOSITE SAMPLE NUMBER	SOIL TYPE
○	E	ML
□	F	SM
△	G	SM
▽	H	SM

CALIFORNIA BEARING RATIO
(CBR) CURVES
DRY LAKE VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
B-7

FUGRO NATIONAL, INC.



SYMBOL	COMPOSITE SAMPLE NUMBER	TRENCH NUMBER	SAMPLE INTERVAL		SOIL TYPE
			FEET	METERS	
———	E	DL-T-8	0.0 - 1.8	0.0 - 0.55	ML
		DL-T-8	3.0 - 5.0	0.91 - 1.52	
— —	F	DL-T-17	0.0 - 1.0	0.0 - 0.30	SM
		DL-T-15	8.0 - 10.0	2.44 - 3.05	
—·—	G	DL-T-12	17.0 - 18.0	5.18 - 5.49	SM
		DL-T-12	BLEND		
—··—	H	DL-T-11	7.0 - 9.0	2.13 - 2.74	SM
		DL-T-1	14.5 - 15.5	4.42 - 4.72	

GRAIN SIZE CURVES, CBR TESTS
DRY LAKE VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

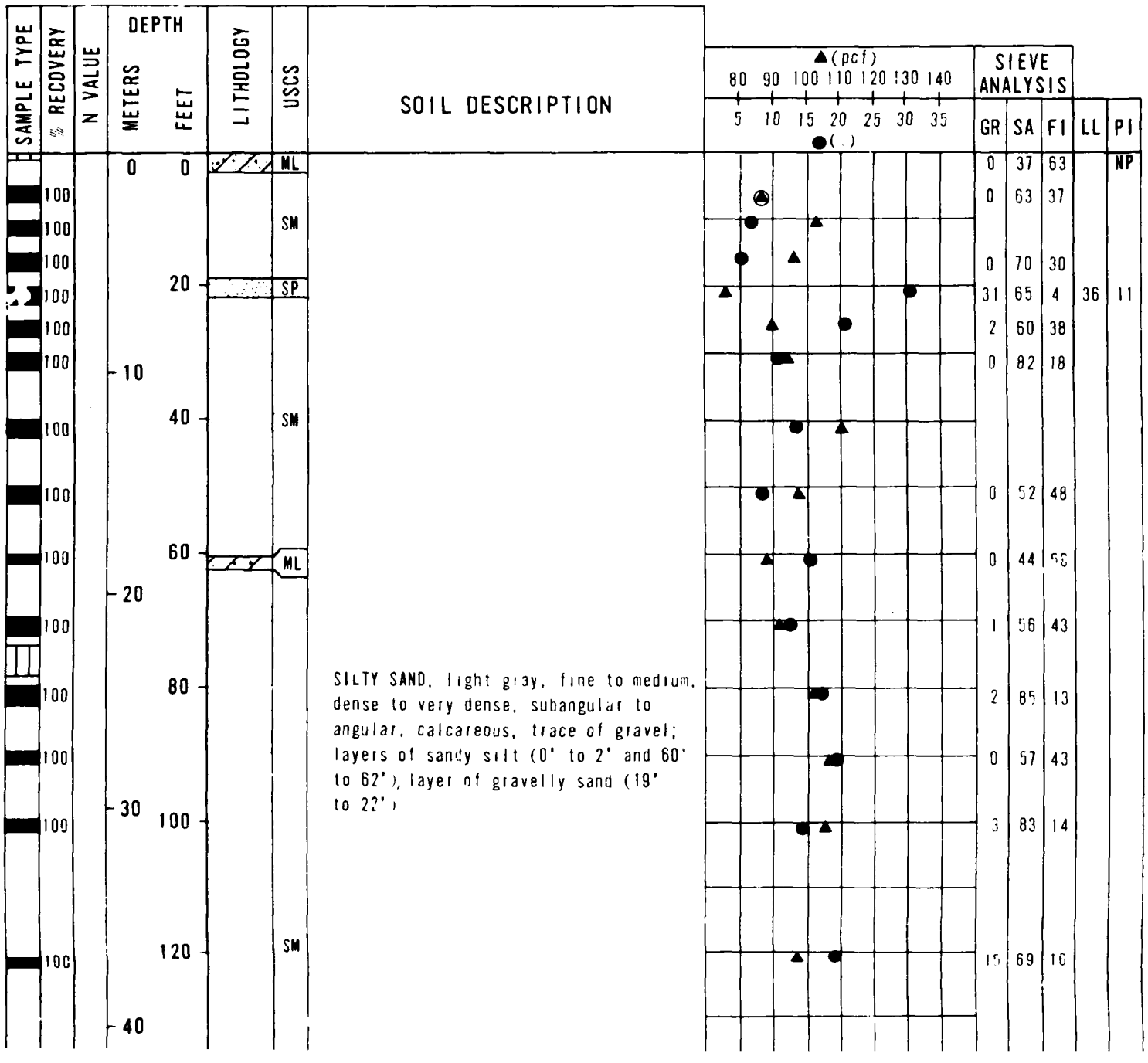
FIGURE
B-8

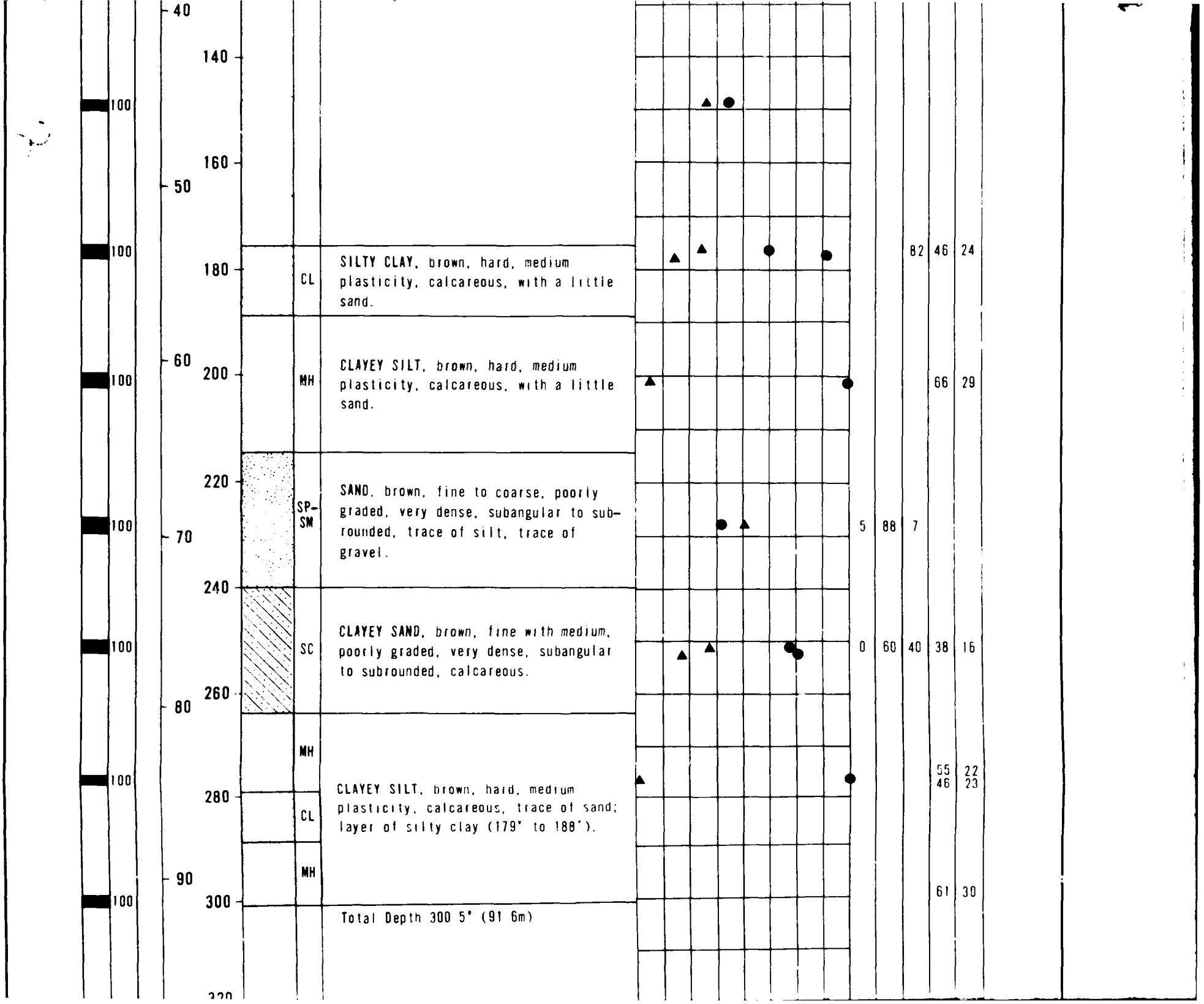
UGRO NATIONAL, INC.

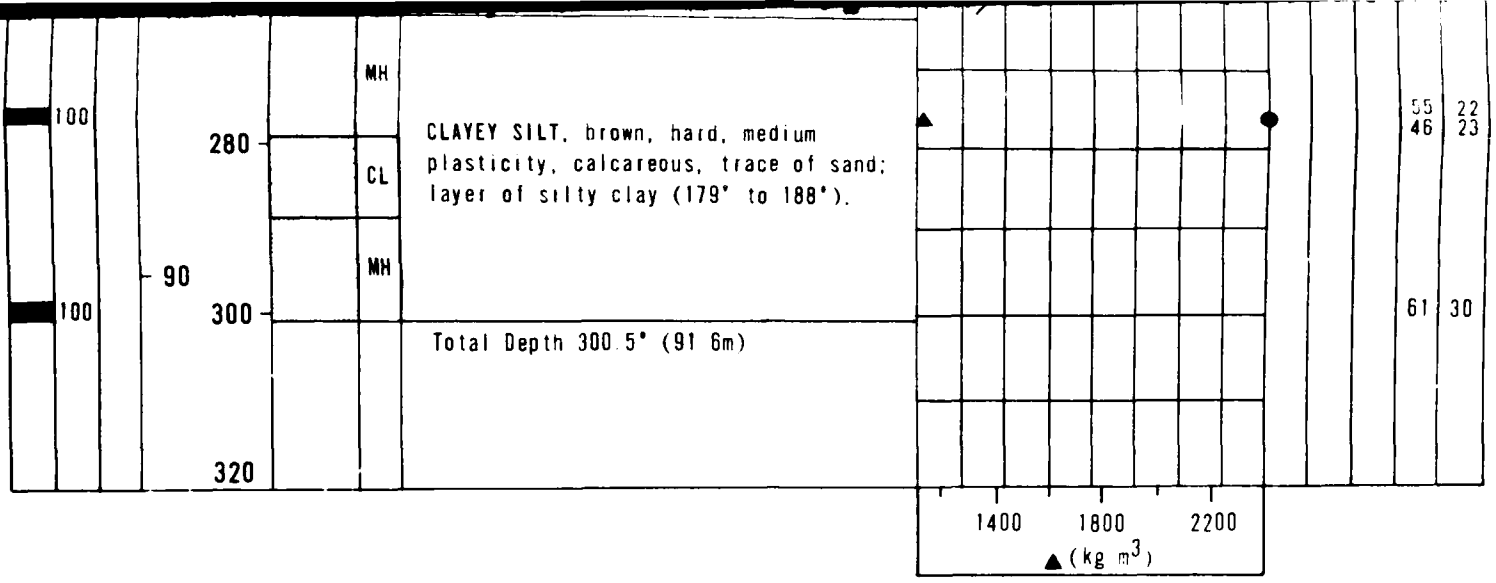
APPENDIX C

GEOTECHNICAL DATA - RALSTON VALLEY

TABLE OF CONTENTS
APPENDIX C


SAMPLE TYPE
% RECOVERY
N VALUE
DEPTH
METERS
FEET
LITHOLOGY
USCS
SOIL DESCRIPTION
▲(pcf)
80 90 100 110 120 130 140
5 10 15 20 25 30 35
●( )
SIEVE ANALYSIS
GR SA FI LL PI
0 37 63 NP
0 63 37
0 70 30
31 65 4 36 11
2 60 38
0 82 18
0 52 48
0 44 56
1 56 43
2 85 13
0 57 43
3 83 14
15 69 16
100
100
100
100
100
100
100
100
100
100
100
100
100
0
20
40
60
80
100
120
10
20
30
40
ML
SM
SP
SM
ML
SM
SILTY SAND, light gray, fine to medium, dense to very dense, subangular to angular, calcareous, trace of gravel; layers of sandy silt (0' to 2' and 60' to 62'), layer of gravelly sand (19' to 22').


40
140
160
50
100
100
180
CL
SILTY CLAY, brown, hard, medium plasticity, calcareous, with a little sand.
82 46 24
60
200
MH
CLAYEY SILT, brown, hard, medium plasticity, calcareous, with a little sand.
66 29
100
220
SP-SM
SAND, brown, fine to coarse, poorly graded, very dense, subangular to subrounded, trace of silt, trace of gravel.
5 88 7
70
240
100
SC
CLAYEY SAND, brown, fine with medium, poorly graded, very dense, subangular to subrounded, calcareous.
0 60 40 38 16
260
80
MH
100
280
CL
CLAYEY SILT, brown, hard, medium plasticity, calcareous, trace of sand; layer of silty clay (179' to 188').
55 22
46 23
MH
90
100
300
Total Depth 300 5' (91 6m)
61 30
320



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE
- CORE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 5182' (1579m)
DATE DRILLED	: 19 AUGUST 1977
DRILLING METHOD	: ROTARY WASH
HOLE DIAMETER	: 4 7 8'' (124mm)
CASING INSTALLED	: 299' (91m)
WATER LEVEL	: Not Encountered

LOG OF BORING RV-B-6
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

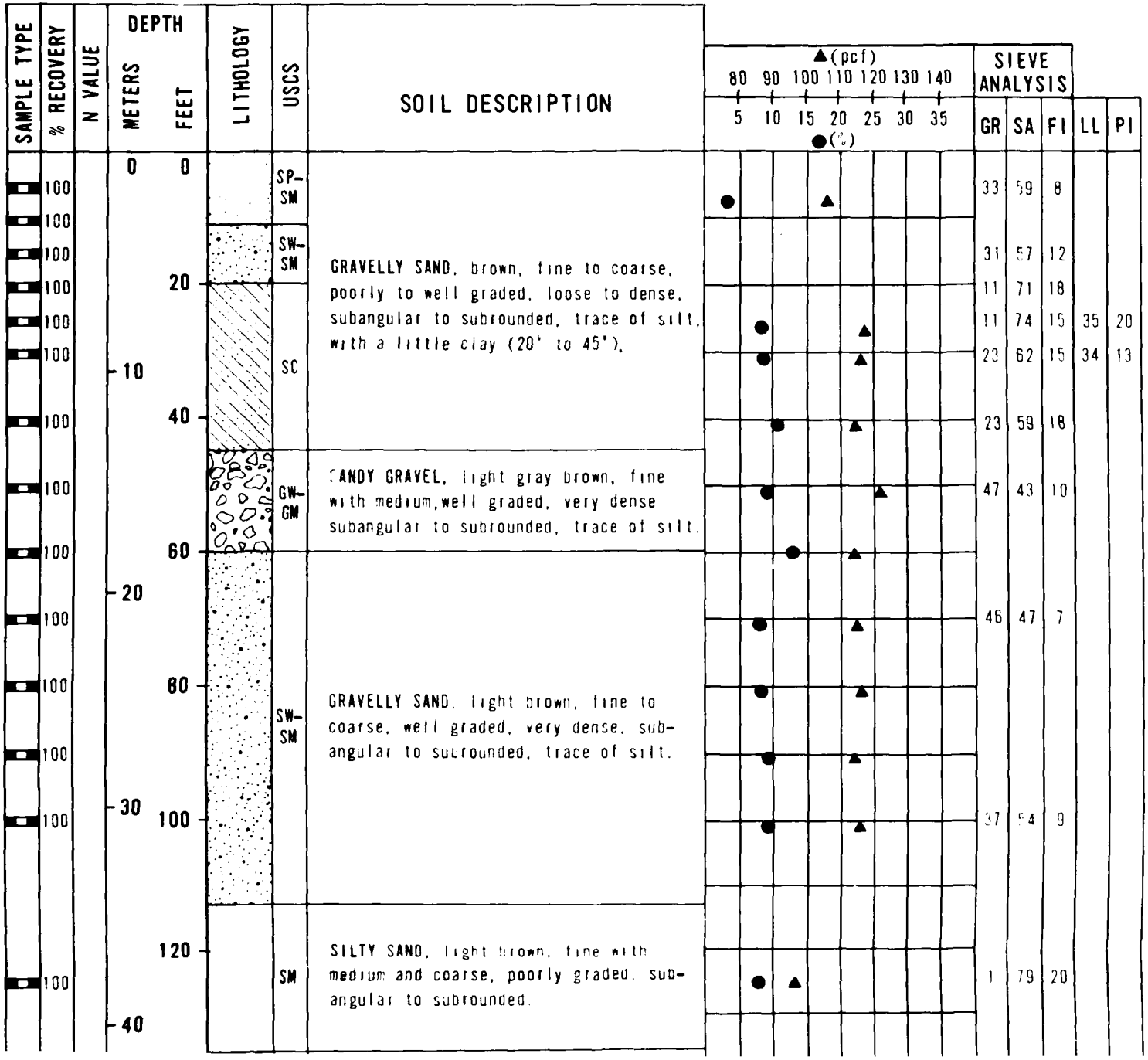
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

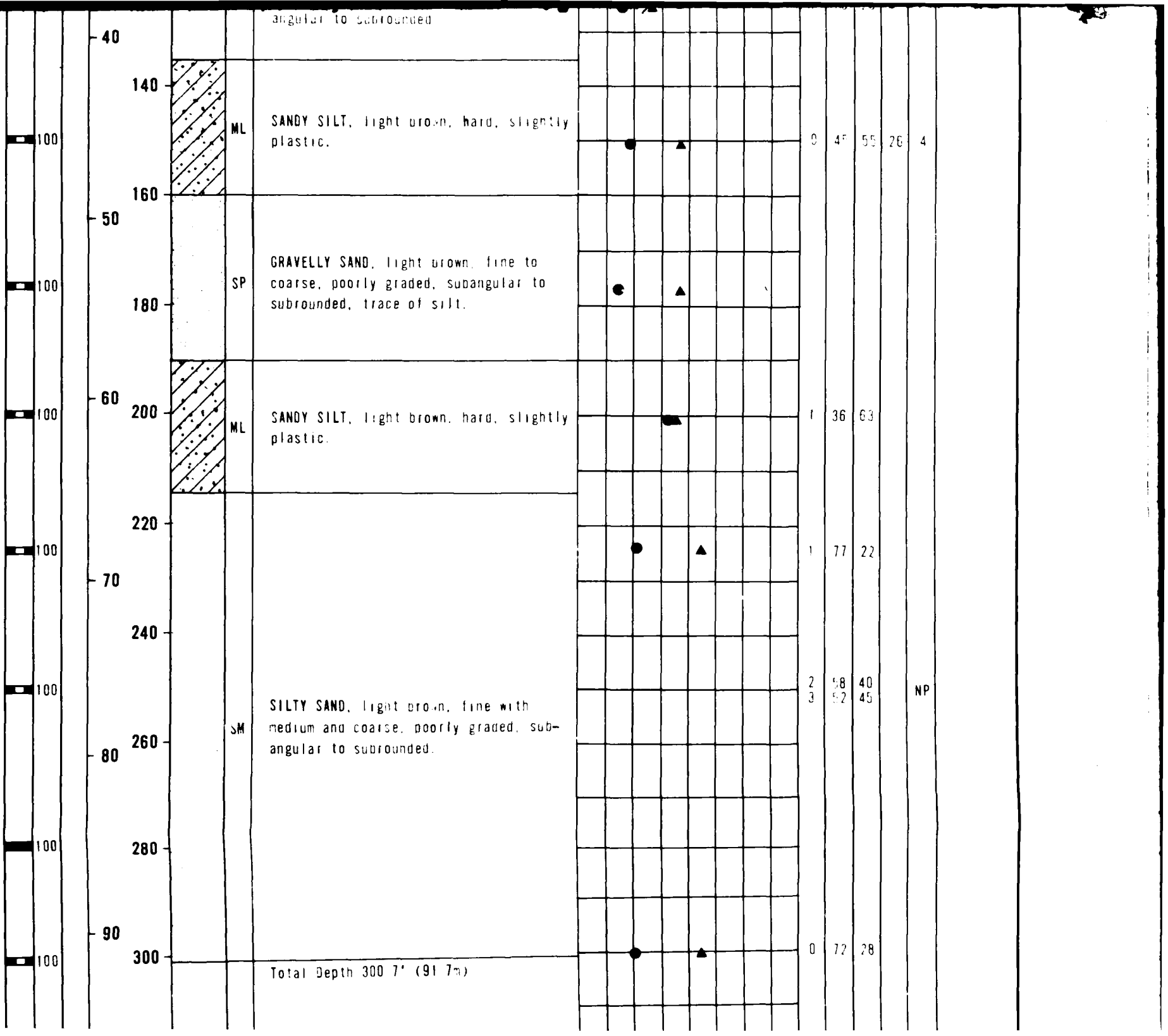
FIGURE C-1

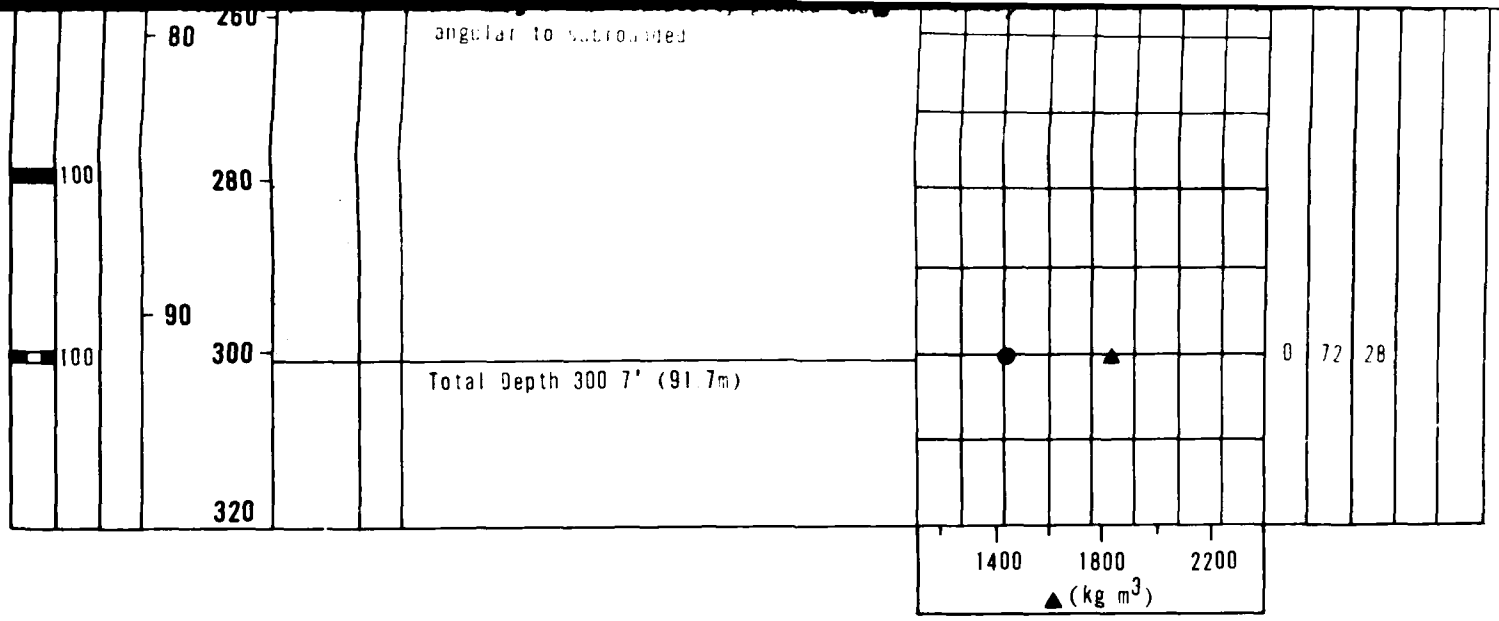
FUGRO NATIONAL, INC.

CHECKED BY _____ APPROVED BY _____

FN-1R-26e




angular to subrounded
40
140
160
50
180
60
200
220
70
240
260
80
280
90
300
100
100
100
100
100
100
ML
SANDY SILT, light brown, hard, slightly plastic.
SP
GRAVELLY SAND, light brown, fine to coarse, poorly graded, subangular to subrounded, trace of silt.
ML
SANDY SILT, light brown, hard, slightly plastic.
SM
SILTY SAND, light brown, fine with medium and coarse, poorly graded, subangular to subrounded.
Total Depth 300 7' (91 7m)
0 45 55 26 4
1 36 63
1 77 22
2 58 40 NP
3 52 45
0 72 28



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE
- CORE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 5335' (1626m)
DATE DRILLED	: 15 AUGUST 1977
DRILLING METHOD	: ROTARY WASH
HOLE DIAMETER	: 4 7 8" (124mm)
CASING INSTALLED	: 143' (44m)
WATER LEVEL	: Not Encountered

LOG OF BORING RV-8-6
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

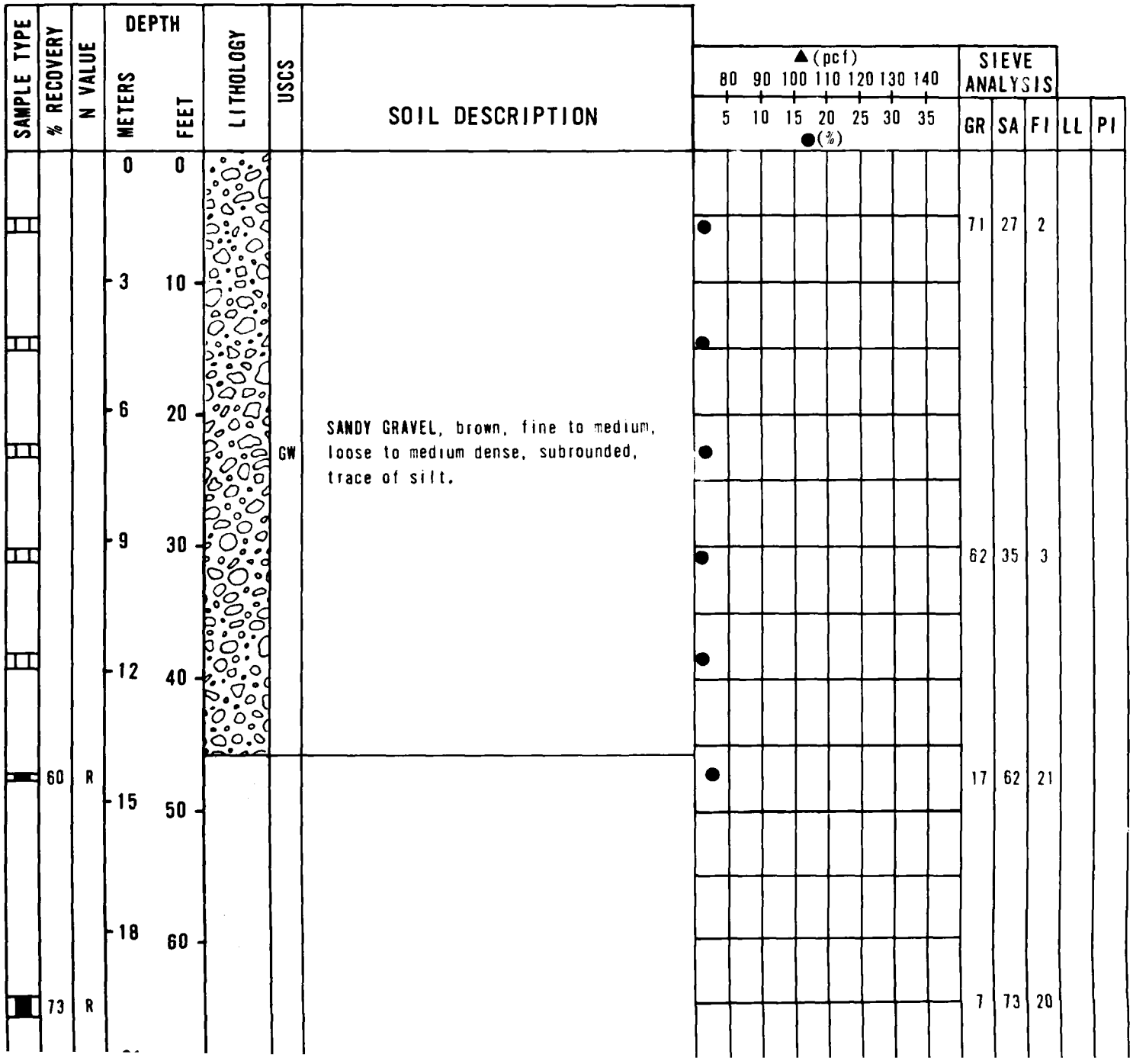
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

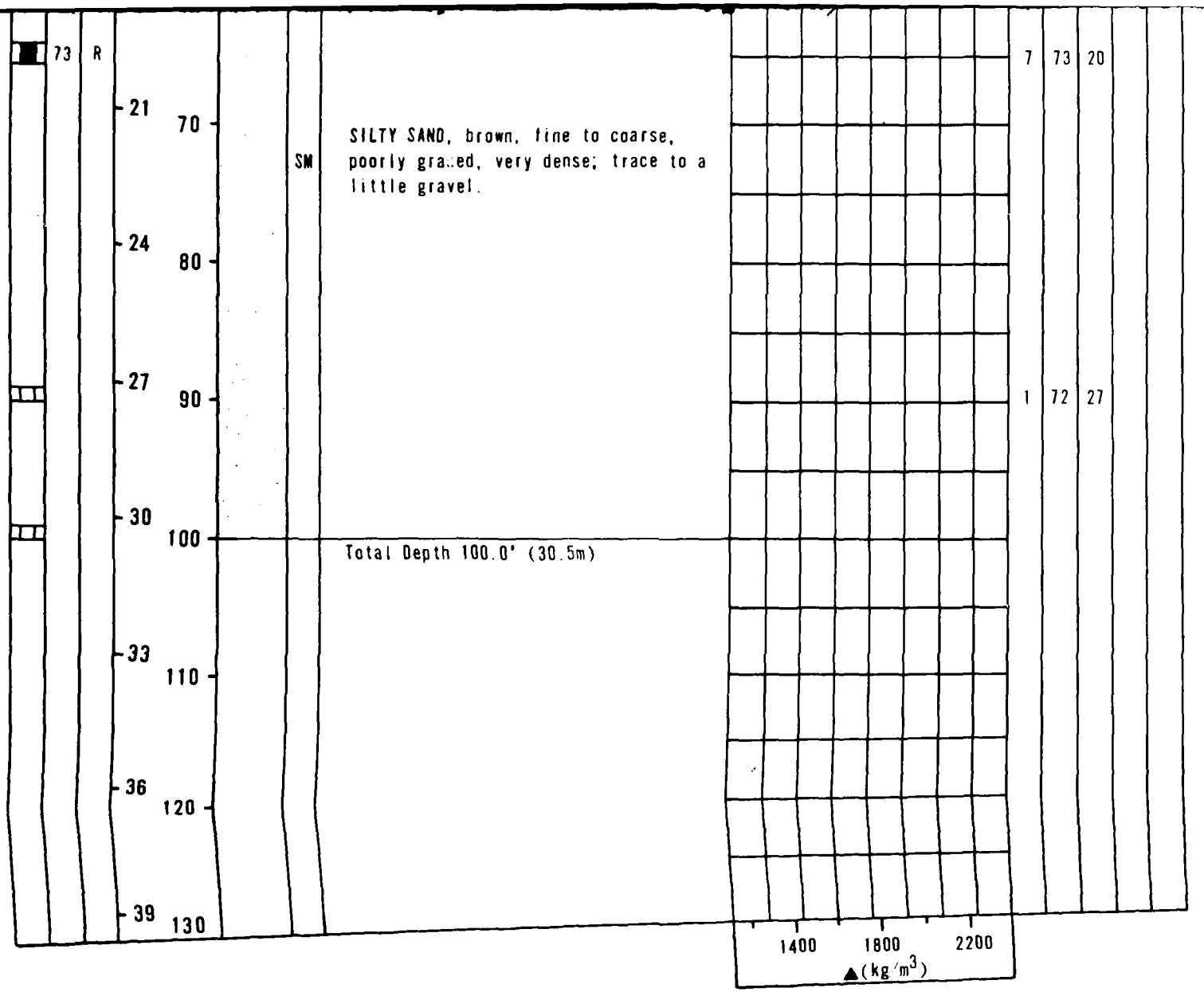
FIGURE C-2

FUGRO NATIONAL, INC.

HECK VED

FN-TR-26a





FUGRO N

LOG OF B
RALSTON
GREAT

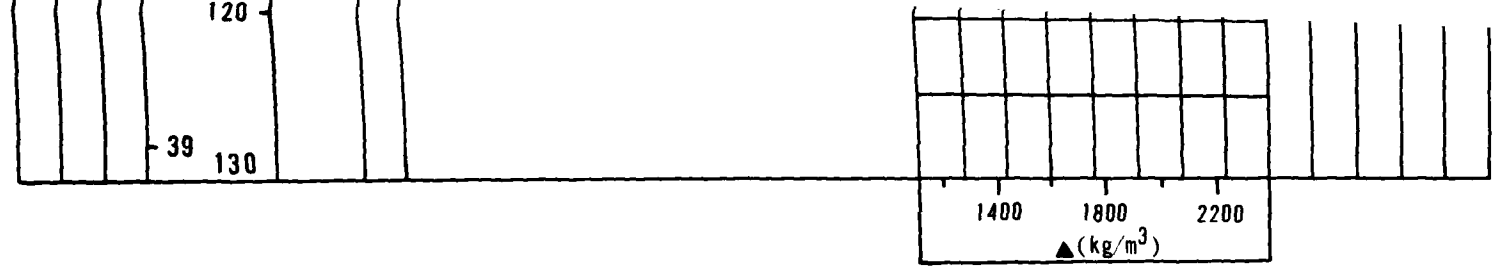
MX SITING INV
DEPARTMENT OF THE

SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE

BORING DETAILS

ELEVATION	: 5380' (1640m)
DATE DRILLED	: 8 AUGUST 1977
DRILLING METHOD	: PERCUSSION
HOLE DIAMETER	: 5 1/2" (140mm)
CASING INSTALLED	: 60' (18m)
WATER LEVEL	: Not Encountered



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 5380' (1640m)
DATE DRILLED	: 8 AUGUST 1977
DRILLING METHOD	: PERCUSSION
HOLE DIAMETER	: 5 1/2" (140mm)
CASING INSTALLED	: 60' (18m)
WATER LEVEL	: Not Encountered

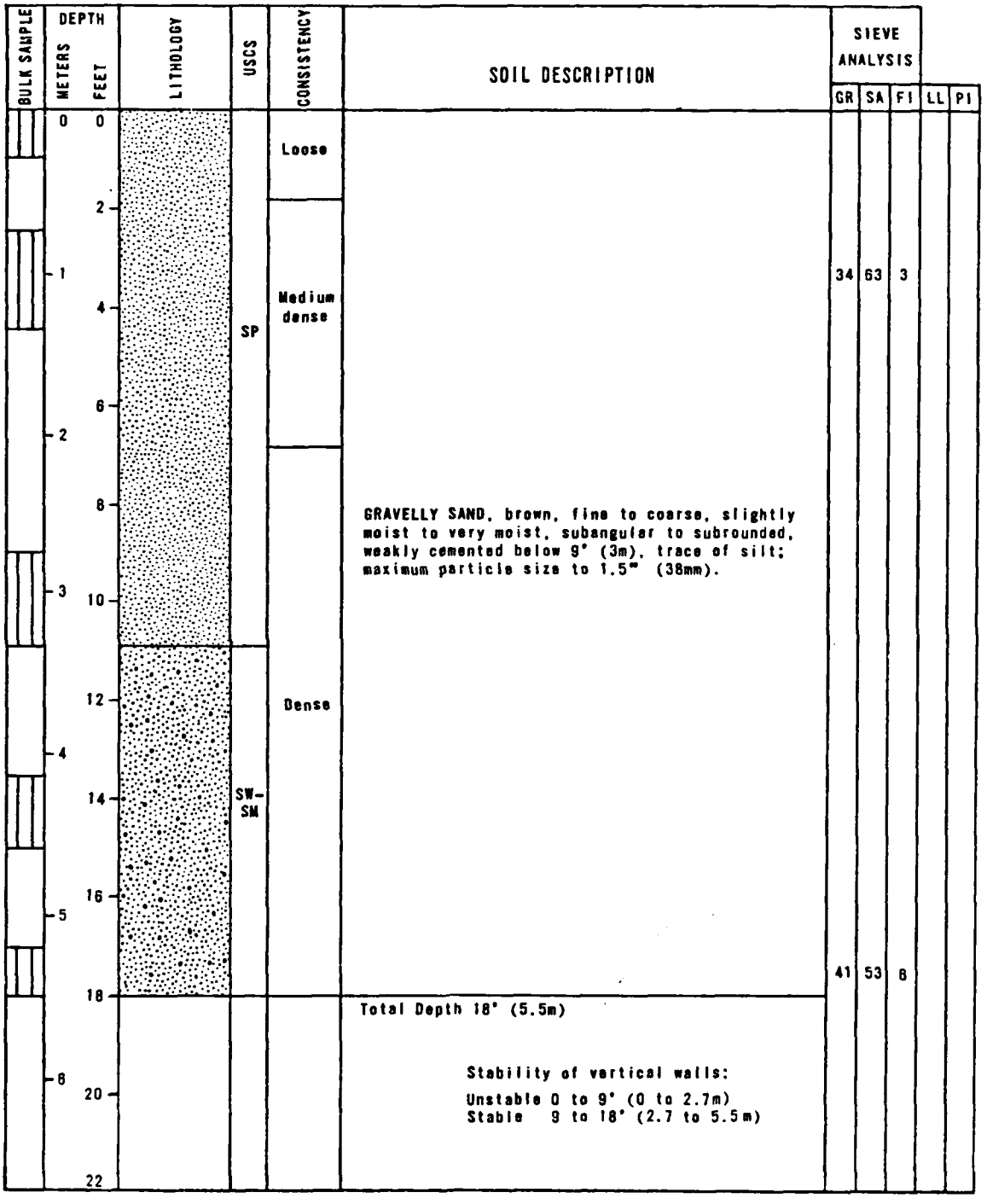
FUGRO NATIONAL, INC.

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE C-3

LOG OF BORING RV-B-16
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

FN-TR-26e



TRENCH DETAILS

SURFACE ELEVATION : 5335' (1626m)
DATE EXCAVATED : 20 August 1977
SURFACE GEOLOGIC UNIT : Au
TRENCH LENGTH : 56' (17m)
TRENCH ORIENTATION : N70E

LOG OF TRENCH RV-T-8
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE · SAMSO

FIGURE C-4

UGRO NATIONAL, INC.

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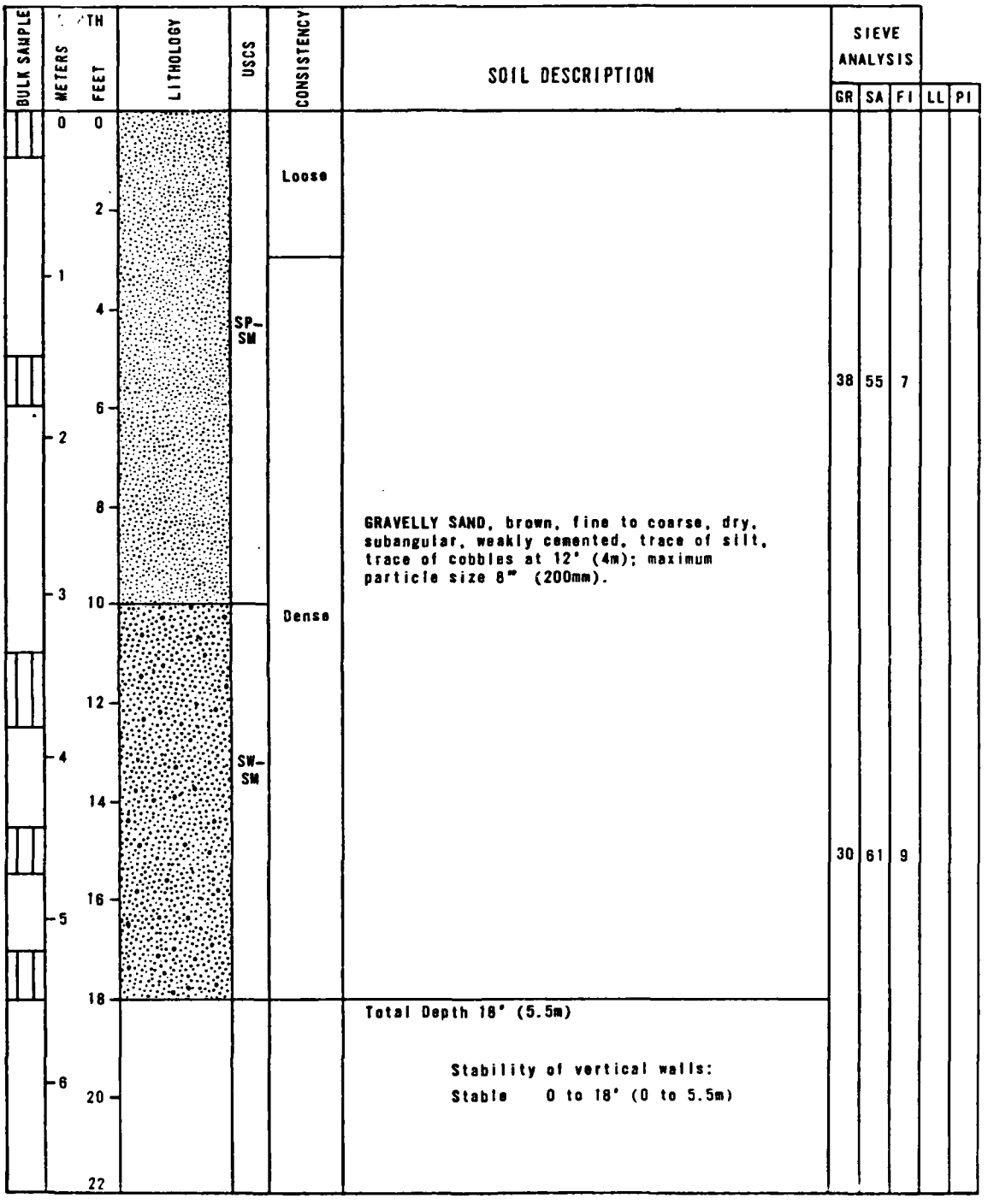
FN-TR-26e



TRENCH DETAILS

SURFACE ELEVATION : 5588' (1703m)
DATE EXCAVATED : 16 August 1977
SURFACE GEOLOGIC UNIT : A5y
TRENCH LENGTH : 85' (26m)
TRENCH ORIENTATION : N70W

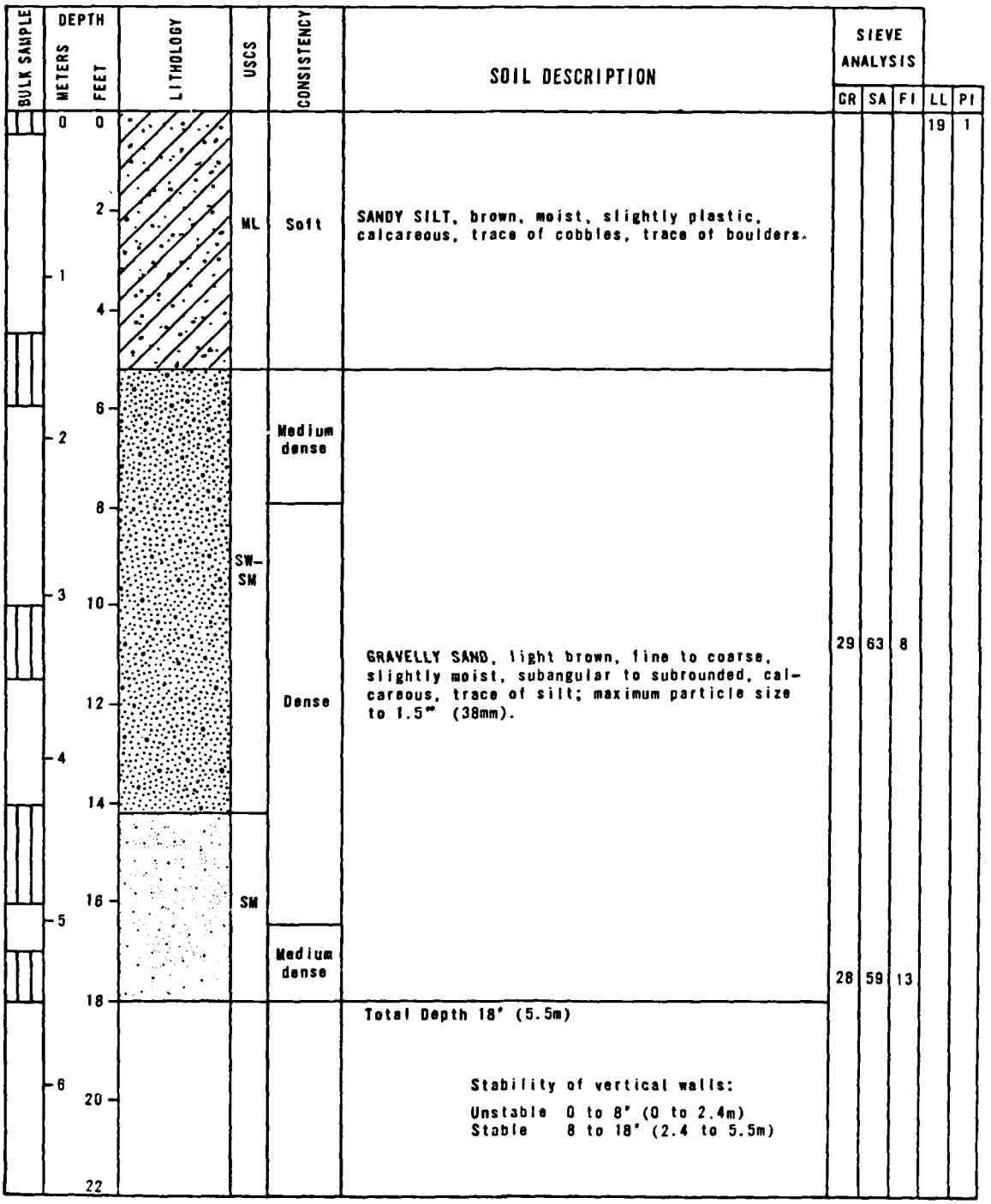
LOG OF TRENCH RV-T-10
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE C-5

UGRO NATIONAL, INC.

FN-TR-26e



TRENCH DETAILS

SURFACE ELEVATION	: 5940' (1811m)
DATE EXCAVATED	: 19 August 1977
SURFACE GEOLOGIC UNIT	: A5i
TRENCH LENGTH	: 68' (21m)
TRENCH ORIENTATION	: N60E

LOG OF TRENCH RV-T-14
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE C-6

UGRO NATIONAL, INC.

BORING NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL		PERCENT FINER BY WEIGHT										
				STANDARD SIEVE OPENING							U S STANDARD SIEVE NO			
				BLDRS.	COBBLES		GRAVEL				SAND			
		FEET	METERS	24"	12"	6"	3"	1½"	3 4"	3 8"	4	10	40	100
RV-B-6	P-1	5.0-5.7	1.52-1.74									100	91	61
	P-2	10.0-10.7	3.05-3.26											
	P-3	15.7-16.3	4.79-4.97									100	97	68
	P-4	20.0-22.7	6.10-6.92						100	91	82	69	29	7
	P-5	25.0-25.7	7.62-7.83							100	98	94	76	54
	P-6	30.0-30.8	9.14-9.39								100	99	89	47
	P-7	40.0-40.8	12.19-12.44											
	P-8	50.1-50.9	15.27-15.51									100	97	85
	P-9	60.1-60.9	18.32-18.56									100	99	89
	P-10	70.1-70.8	21.37-21.58							100	99	98	90	75
	P-12	80.1-80.8	24.41-24.63							100	98	94	66	30
	P-13	90.1-90.8	27.46-27.68								100	97	82	70
	P-14	100.1-100.8	30.51-30.72							100	98	91	67	33
	P-15	121.0-121.7	36.88-37.09						100	97	85	72	56	41
	P-16	149.1-149.8	45.45-45.66											
	P-17	176.1-176.9	53.68-53.92											
		176.1-176.9	53.68-53.92											
		176.9-178.6	53.92-54.44											
	P-18	200.2-201.0	61.02-61.26											
		200.2-201.0	61.02-61.26											
	P-19	227.5-228.2	69.34-69.56							100	95	81	40	15
	P-20	250.1-250.9	76.23-76.47									100	92	70
		250.1-250.9	76.23-76.47											
	P-21	276.1-276.8	84.16-84.37											
	P-22	299.9-300.4	91.41-91.56											

NOTES:

(a) Sample types
- SS - Standard split spoon
- P - Pitcher
- D - Fugro Drive
- B - Bulk

(b) NP - Not Plastic

(c) USCS - Unified Soil Classification System; Table A-I

(d) *Indicates that test has been performed and results are included in this report

APPROVED BY

CHECKED BY

NDARD SIEVE NO			PARTICLE SIZE (mm)		ATTERBERG LIMITS (b)			USCS (c)	IN-SITU					COMPACTED			SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION
AND			SILT OR CLAY						DRY UNIT WEIGHT		MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)					
40	100	200	.005	.001	LL	PL	PI		(pcf)	(kg m^3)				(pcf)	(kg m^3)						
91	61	37	9	4				SM	87.0	1394	8.4	24	.93							*	
								SM	103.0	1650	6.5	28	.64							*	
97	68	30						SM	97.4	1560	5.7	21	.73							*	
29	7	4	2	1	36	25	11	SP	75.6	1211	30.0	66	1.23						*		
76	54	38						SM	90.5	1450	20.9	65	.86								
89	47	18						SM	93.5	1498	11.5	39	.72				2.58				
								SM	110.1	1764	13.8	70	.53								
97	85	48	4	1				SM	97.0	1554	8.6	32	.74					*			
99	89	56	11	7				ML	89.2	1429	15.4	47	.81				2.59				
90	75	43						SM	92.3	1479	11.9	39	.83					*			
66	30	13						SM	102.7	1645	16.7	70	.64								
82	70	43						SM	107.0	1714	18.7	88	.57					*			
67	33	14						SM	105.5	1690	14.4	65	.59								
56	41	16	5	1				SM	97.6	1563	18.8	70	.73								
								SM	96.6	1547	17.1	62	.74								
					46	23	24	CL	94.4	15.	24.9	86	.78								
								CL	89.3	1430	30.6	93	.89						*		
		82						CL	84.0	1346	35.9	96	1.01						*		
					66	37	29	MH	74.4	1192	44.3	94	1.15				2.56		*		
								MH	75.7	1213	41.5	91	1.23								
40	15	7						SP-SM	110.2	1765	16.3	84	.53								
92	70	40	13	7	38	22	16	SC	88.6	1422	28.8	87	.90						*		
								SC	80.6	1294	30.4	90	1.09								
					55	34	22	MH	80.4	1288	36.9	91	1.10						*		
					61	31	30	MH											*		

SUMMARY OF LABORA
BORING
RALSTON VALLEY, NEVA

MX SITING INVES
DEPARTMENT OF THE AIR

FUGRO NAT

VOID RATIO	COMPACTED: MAXIMUM DRY DENSITY (pcf)	COMPACTED: MAXIMUM DRY DENSITY ($kg\ m^3$)	COMPACTED: OPTIMUM MOISTURE (%)	SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL (d)	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	RELATIVE DENSITY
.93							*			
.64							*			
.73							*			
.23						*			*	
.86										
.72				2.58						
.53										
.74					*					
.81				2.59						
.83					*					
.64										
.57					*					
.59										
.73										
.74										
.78										
.89						*				
1.01						*				
1.15				2.56		*				
1.23										
.53										
.90						*				
1.09										
1.10						*				
						*				

SUMMARY OF LABORATORY TEST RESULTS
BORING RV-B-6
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
C-1

FUGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	UNCONFINED COMP. STRENGTH		DRY DENSITY		MOISTURE CONTENT (%)	DEGREE OF SATURATION (%)	HEIGHT DIAMETER
		FEET	METERS		ksf	kN m^2	pcf	kg/m^3			
RV-B-1	P-20	247.0-247.8	75.29-75.53	SM	2.8	134	77.0	1233	40.8	92.6	2.4
RV-B-6	P-4	20.0-20.7	6.10-6.31	SP	2.1	101	81.2	1301	23.3	58.5	2.4
	P-17	176.1-176.9	53.68-53.92	CL	5.4	259	89.3	1430	30.6	93.0	2.4
	P-17	178.0-178.6	54.25- 54.44	CL	6.5	311	82.5	1322	37.3	96.7	2.4
	P-18	200.2-201.0	61.02-61.26	MH	5.5	263	74.4	1192	44.3	94.5	2.4
	P-20	251.9-252.6	76.78-76.99	SC	7.9	378	87.6	1403	32.3	94 3	2.4
	P-21	276.1-276.8	84.16-84.37	MH	8.5	407	80.4	1288	36.9	91.0	2.4
	P-22	299.4-299.9	91.26-91.41	MH	4.8	230	71.7	1149	46.1	92 3	2.4
RV-B-7	P-4	20.0-20.8	6.10-6.34	ML	7.0	335	96.8	1551	20.1	73.4	2.4
	P-6	30.0-30.8	9.14-9.39	ML	14.4	689	110.0	1762	13.8	72.0	2.4
	P-11	81.0-81.7	24.69-24.90	ML	2.8	134	83.6	1339	24.2	64.5	2.4
RV-B-8	D-19	250.2-250.9	76.26-76.47	SM	6.1	292	114.2	1829	12.0	68.1	2.4

SUMMARY OF UNCONFINED COMPRESSION TEST RESULTS
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

TABLE C-2

UGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	TYPE OF TEST	DRY DENSITY		MOISTURE CONTENT	CONFINING PRESSURE (σ_3)		MAXIMUM DEVIATOR STRESS ($\sigma_1-\sigma_3$)		STRAIN RATE	BACK PRESSURE	
		FEET	METERS			pcf	kg/m^3	(%)	ksf	kN/m^2	ksf	kN/m^2	(% min)	ksf	kN/m^2
RV-B-1	D-3	15.5-16.0	4.72-4.88	SP-SM	CD	107.7	1725	8.2	1.7	81	14.5	694	.07	0	0
	D-4	20.5-21.0	6.25-6.40	GP-GM	CD	118.7	1901	5.4	4.0	192	25.7	1230	.07	0	0
	D-5	25.0-26.0	7.62-7.92	SC	CD	109.4	1752	8.8	8.9	426	36.5	1747	.07	0	0
	D-8	50.5-51.0	15.39-15.54	SC	CD	118.1	1892	8.5	5.5	263	27.1	1297	.07	0	0
	D-9	61.2-61.7	18.65-18.81	SC	CD	117.6	1884	8.8	12.4	594	64.4	3083	.09	0	0
	D-10	70.3-70.8	21.43-21.58	SW-SM	CD	102.6	1643	14.6	26.9	1288	110.6	5295	.07	0	0
	D-13	90.2-91.9	27.49-28.01	SM	CD	108.9	1744	13.3	9.9	474	45.1	2159	.07	0	0
	D-14	100.2-100.7	30.54-30.69	SM	CD	121.4	1945	10.3	20.2	967	23.5	1125	.07	0	0
	D-15	128.2-128.7	39.08-39.23	SM	CD	110.3	1767	12.7	44.6	2135	167.0	7995	.07	0	0
RV-B-5	P-3	15.0-15.8	4.57-4.82	SM	CD	110.6	1772	13.1	1.7	81	13.1	627	.07	0	0
	P-4	20.0-20.8	6.10-6.34	SP-SM	CD	100.8	1615	9.1	3.8	182	14.5	694	.07	0	0
	P-5	25.0-25.8	7.62-7.86	SM	CD	101.1	1619	7.7	8.6	412	30.0	1436	.07	0	0
RV-B-6	P-8	50.1-50.9	15.27-15.51	SM	CD	93.3	1495	12.1	5.5	263	32.0	1532	.07	0	0
	P-10	70.1-70.8	21.37-21.58	SM	CD	95.2	1525	8.3	12.7	608	54.9	2628	.07	0	0
	P-13	90.1-90.8	27.46-27.68	SM	CD	106.2	1701	15.8	31.0	1484	121.2	5803	.07	0	0
RV-B-8	D-2	10.7-11.2	3.26-3.41	SP-SM	CD	100.4	1608	12.6	1.2	57	7.7	369	.08	0	0
	D-3	15.3-15.8	4.66-4.82	SW-SM	CD	115.8	1855	7.8	3.3	158	18.1	867	.07	0	0
	D-4	20.4-20.9	6.22-6.37	SC	CD	116.9	1873	7.4	8.8	421	45.4	2178	.07	0	0
RV-B-12	D-2	10.2-10.9	3.11-3.32	GP-GM	CD	112.1	1796	11.6	1.2	57	8.7	417	.07	0	0
	D-3	15.4-15.9	4.69-4.85	SW-SM	CD	116.4	1865	5.4	2.9	139	21.5	1029	.07	0	0
	D-4	20.3-20.8	6.19-6.34	SM	CD	111.5	1786	9.7	5.8	278	26.9	1288	.07	0	0

SUMMARY OF TRIAXIAL SHEAR TEST RESULTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

TABLE C-3

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

UGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	NORMAL STRESS		MAXIMUM SHEAR STRENGTH	
		FEET	METERS		ksf	kN/m^2	ksf	kN/m^2
RV-B-5	P-4	20.8-21.1	6.34-6.43	SP-SM	4.0	192	3.2	153
	P-5	25.8-26.1	7.86-7.96	SM	8.0	383	6.8	326
RV-B-6	P-1	5.0-5.7	1.52-1.74	SM	1.0	48	1.2	57
	P-1	5.0-5.7	1.52-1.74	SM	2.0	96	1.9	91
	P-2	10.0-10.7	3.05-3.26	SM	1.0	48	1.1	53
	P-2	10.0-10.7	3.05-3.26	SM	2.0	96	1.9	91
	P-2	10.0-10.7	3.05-3.26	SM	4.0	192	5.1	244
	P-3	15.7-16.3	4.79-4.97	SM	1.5	72	1.6	77
	P-3	15.7-16.3	4.79-4.97	SM	3.0	144	3.0	144
	P-3	15.7-16.3	4.79-4.97	SM	6.0	287	5.2	249
RV-B-7	P-1	5.0-5.7	1.52-1.74	SW-SM	0.5	24	0.7	34
	P-1	5.0-5.7	1.52-1.74	SW-SM	1.0	48	1.3	62
	P-1	5.0-5.7	1.52-1.74	SW-SM	2.0	96	2.0	96
RV-B-12	P-6	30.0-30.7	9.14-9.36	SM	3.0	144	2.7	129
	P-8	48.0-48.7	14.63-14.84	SM	10.0	479	10.8	517
RV-B-13	P-8	50.0-50.8	15.24-15.48	ML	6.0	287	4.2	201

SUMMARY OF DIRECT SHEAR TEST RESULTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE C-4

FUGRO NATIONAL, INC.

COMPOSITE SAMPLE NUMBER	SOIL TYPE	PERCENT PASSING #200	ATTERBERG LIMITS		SPECIFIC GRAVITY	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)	COMPACTED DRY DENSITY		COMPACTED MOISTURE (%)	PERCENT OF MAXIMUM DRY DENSITY	CBR (%)
			LL	PI		pcf	kg/m3		pcf	kg/m3			
A	SW-SM	12			2.46	122.1	1956	9.8	120.6	1932	9.4	98.8	82
									117.0	1874	9.7	95.8	48
									113.2	1813	9.5	92.7	18
B	SP	4			2.60	121.0	1938	10.0	118.1	1892	9.7	97.6	97
									115.9	1857	9.7	95.8	72
									112.8	1807	9.7	93.2	41
C	SM	24			2.46	118.0	1890	11.5	112.7	1805	11.9	95.5	69
									110.4	1768	11.6	93.6	51
									105.0	1682	12.1	89.0	24

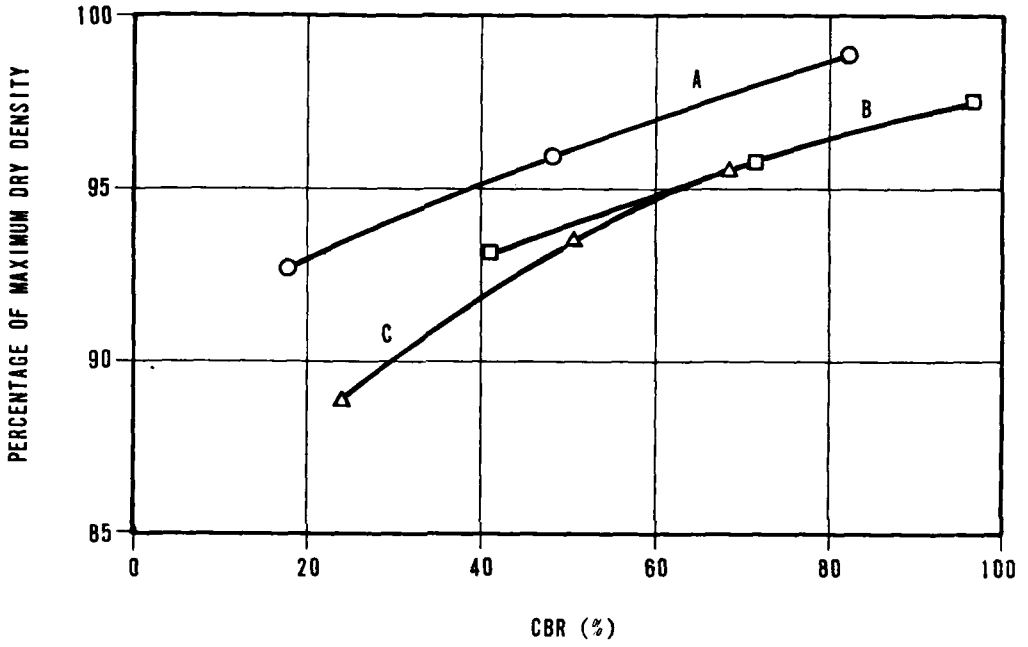
CALIFORNIA BEARING RATIO (CBR) TEST RESULTS

RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE C-5

FUGRO NATIONAL, INC.



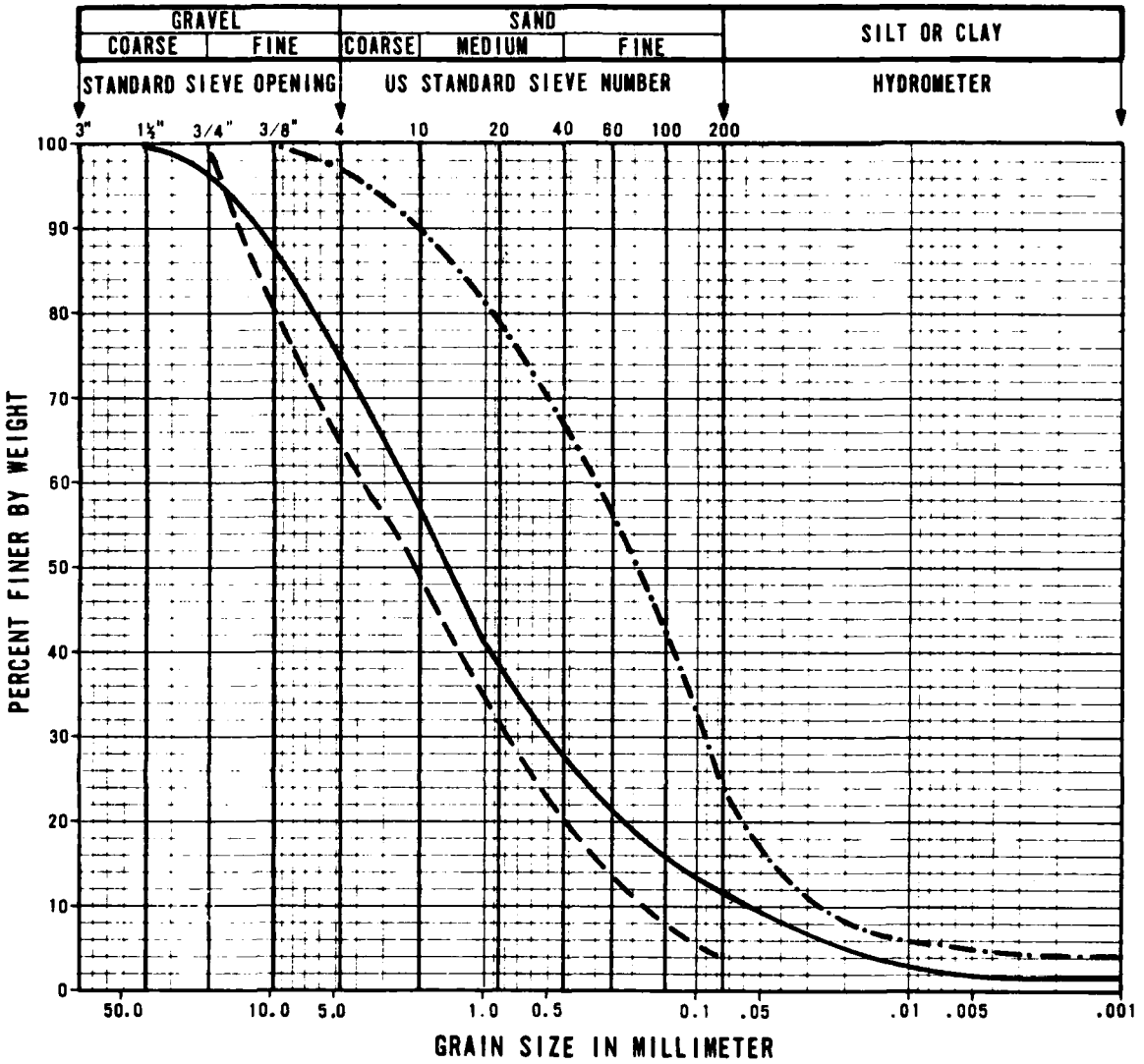
SYMBOL	COMPOSITE SAMPLE NUMBER	SOIL TYPE
○	A	SW-SM
□	B	SP
△	C	SM

CALIFORNIA BEARING RATIO
(CBR) CURVES
RALSTON VALLEY, NEVADA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
C-7

UGRO NATIONAL, INC.



SYMBOL	COMPOSITE SAMPLE NUMBER	TRENCH NUMBER	SAMPLE INTERVAL		SOIL TYPE
			FEET	METERS	
——	A	RV-T-10	14.5 - 15.5	4.42 - 4.72	SW-SM
		RV-T-14	10.0 - 11.5	3.05 - 3.51	
— —	B	RV-T-8	2.5 - 4.5	0.76 - 1.37	SP
		RV-T-9	2.5 - 5.0	0.76 - 1.52	
—·—	C	RV-T-7	2.0 - 3.0	0.61 - 0.91	SM
		RV-T-7	16.5 - 18.0	5.03 - 5.49	

GRAIN SIZE CURVES, CBR TESTS
RALSTON VALLEY, NEVADA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
C-8

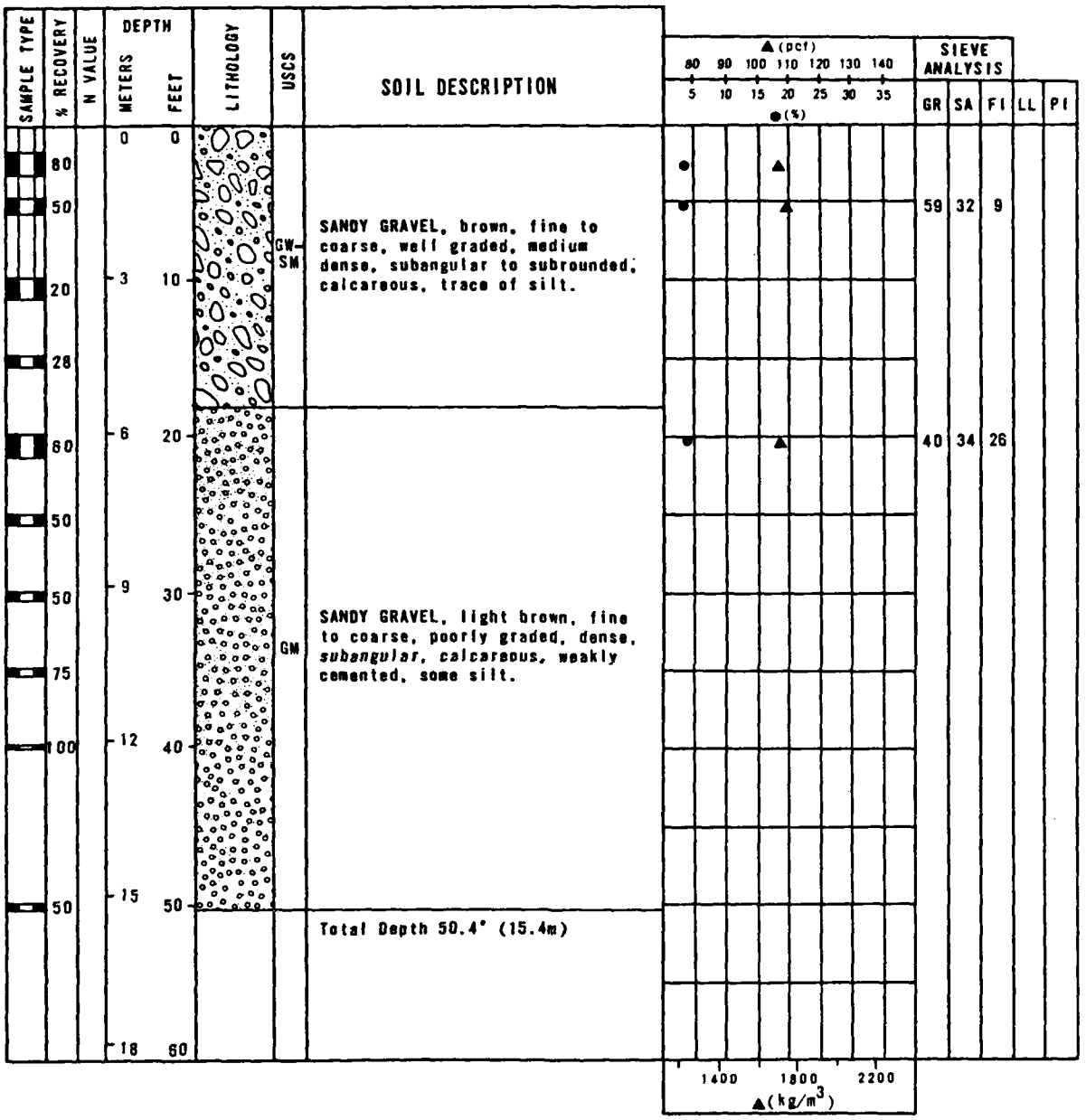
FUGRO NATIONAL, INC.

APPENDIX D

GEOTECHNICAL DATA - SACRAMENTO VALLEY

TABLE OF CONTENTS
APPENDIX D

FN-TR-26e



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE

ENGINEERING PARAMETERS

N — STANDARD PENETRATION TEST (ASTM: D-1586-67)
R — N VALUE GREATER THAN 100 BLOWS/FOOT
▲ — DRY UNIT WEIGHT (ASTM: D-2937-71)
● — MOISTURE CONTENT (ASTM: D-2216-71)
NR — NO RECOVERY

BORING DETAILS

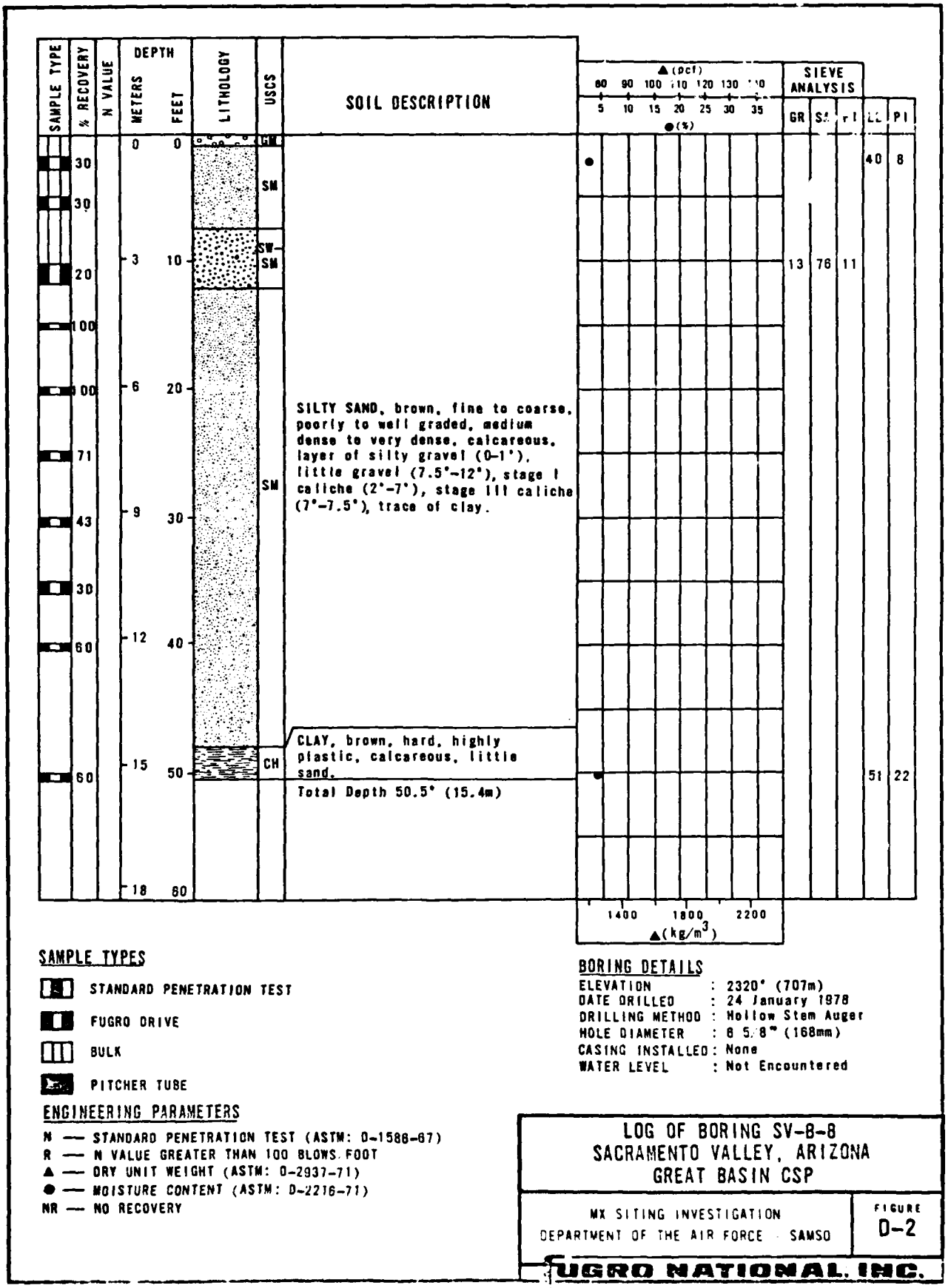
ELEVATION : 2520' (768m)
DATE DRILLED : 24 January 1978
DRILLING METHOD : Hollow Stem Auger
HOLE DIAMETER : 6 5/8" (168mm)
CASING INSTALLED : None
WATER LEVEL : Not Encountered

LOG OF BORING SV-B-3
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE D-1

FUGRO NATIONAL, INC.



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE

ENGINEERING PARAMETERS

N — STANDARD PENETRATION TEST (ASTM: D-1586-67)
R — N VALUE GREATER THAN 100 BLOWS/FOOT
▲ — DRY UNIT WEIGHT (ASTM: D-2937-71)
● — MOISTURE CONTENT (ASTM: D-2216-71)
NR — NO RECOVERY

BORING DETAILS

ELEVATION	: 2320' (707m)
DATE DRILLED	: 24 January 1978
DRILLING METHOD	: Hollow Stem Auger
HOLE DIAMETER	: 8 5/8" (168mm)
CASING INSTALLED	: None
WATER LEVEL	: Not Encountered

LOG OF BORING SV-8-8
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

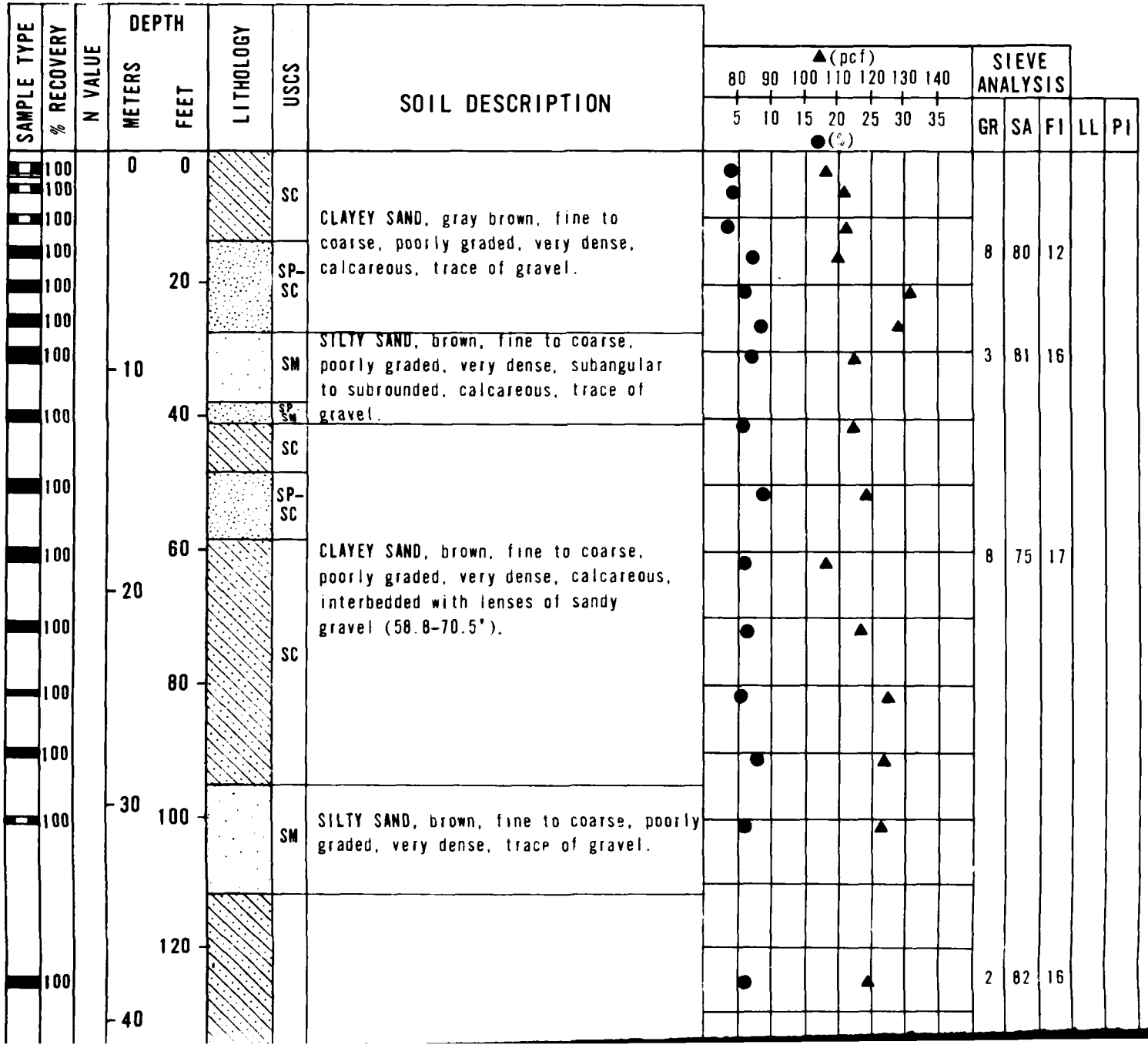
MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

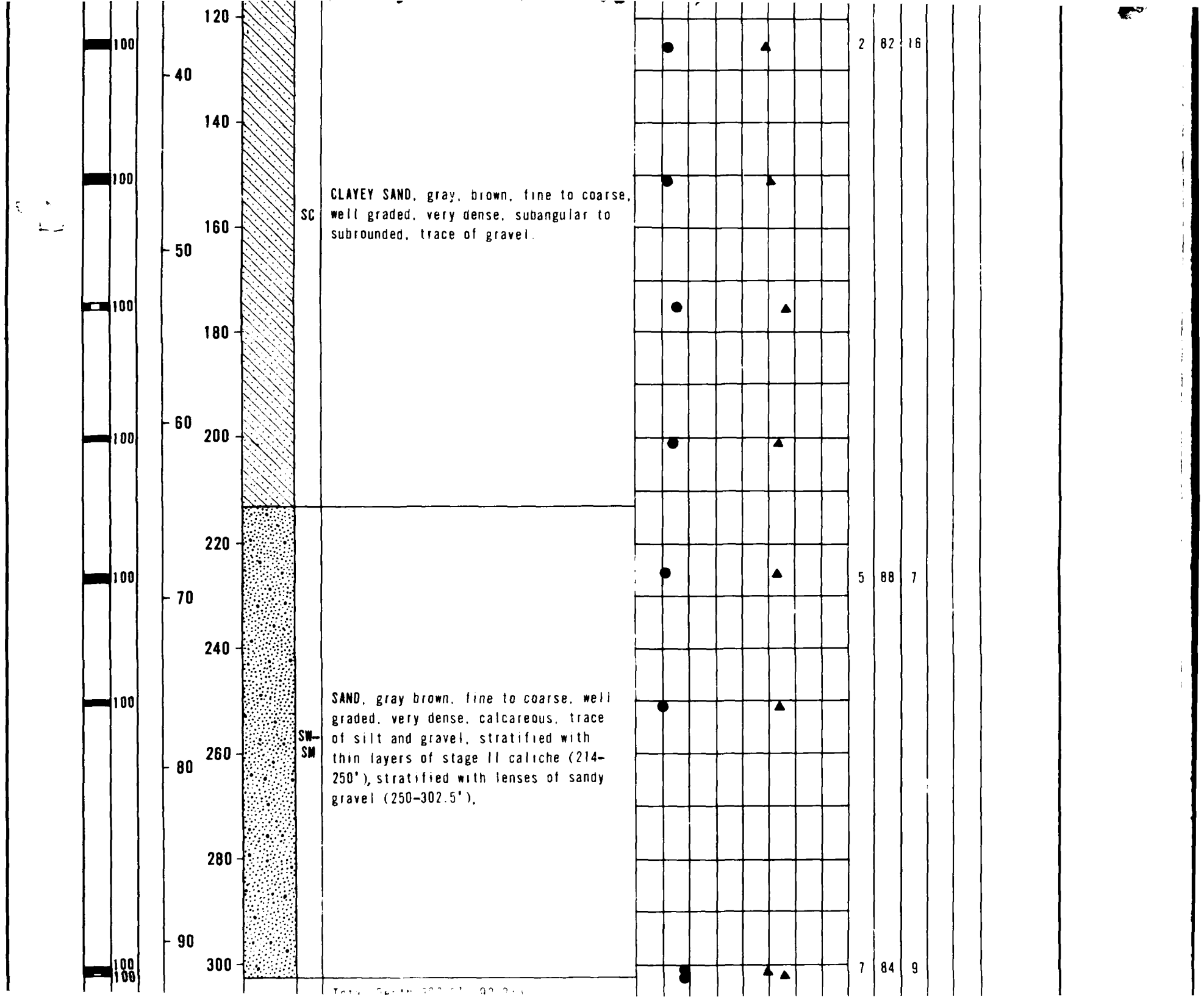
FIGURE D-2

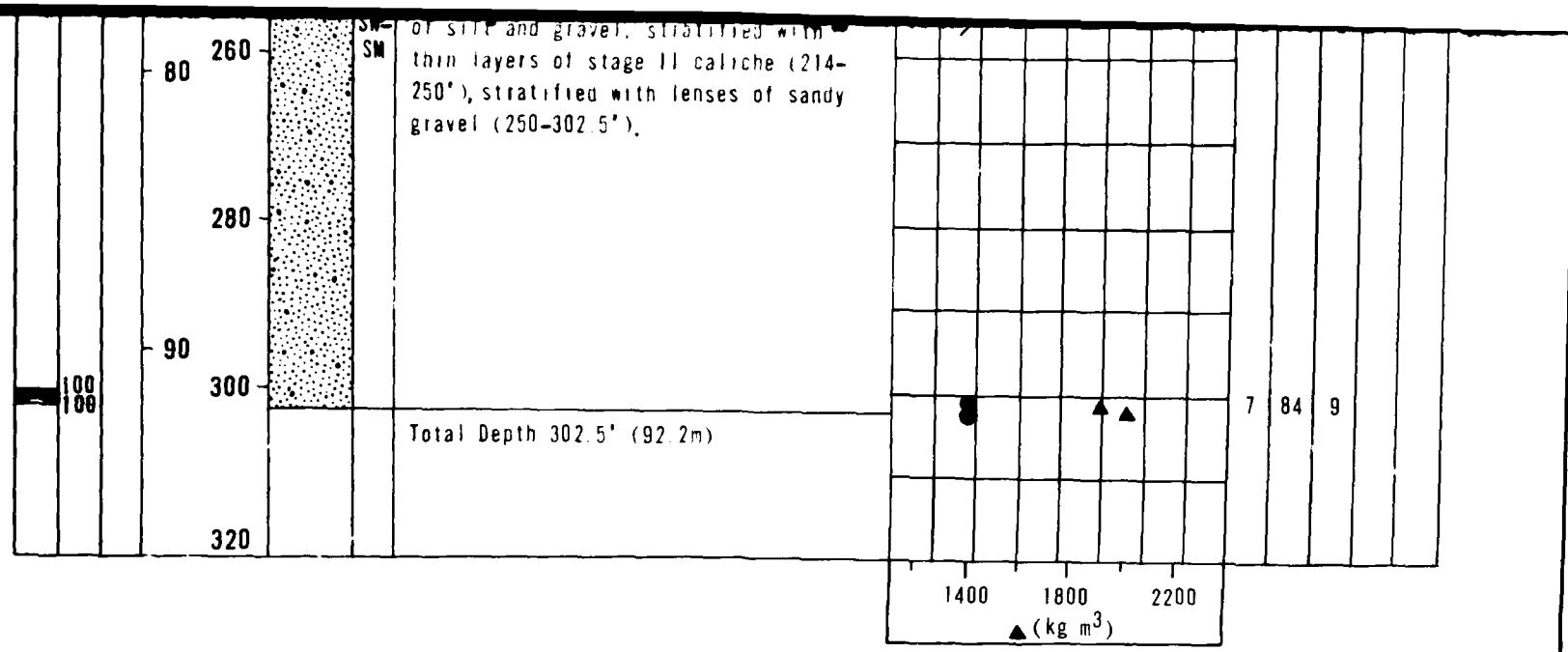
FUGRO NATIONAL, INC.

CHECKED BY _____ APPROVED BY _____

FN-TR-26e




100
100
100
100
100
100
100
100
100
40
50
60
70
80
90
120
140
160
180
200
220
240
260
280
300
SC
SW–SM
CLAYEY SAND, gray, brown, fine to coarse, well graded, very dense, subangular to subrounded, trace of gravel.
SAND, gray brown, fine to coarse, well graded, very dense, calcareous, trace of silt and gravel, stratified with thin layers of stage II caliche (214–250'), stratified with lenses of sandy gravel (250–302.5').
2 82 16
5 88 7
7 84 9



SAMPLE TYPES

- STANDARD PENETRATION TEST
- FUGRO DRIVE
- BULK
- PITCHER TUBE
- CORE

ENGINEERING PARAMETERS

N – STANDARD PENETRATION TEST (ASTM: D-1586-67)
R – N VALUE GREATER THAN 100 BLOWS/FOOT
▲ – DRY UNIT WEIGHT (ASTM: D-2937-71)
● – MOISTURE CONTENT (ASTM: D-2216-71)
NR – NO RECOVERY

BORING DETAILS

ELEVATION	: 1940' (591m)
DATE DRILLED	: 27 January 1978
DRILLING METHOD	: Rotary Wash
HOLE DIAMETER	: 4 7/8" (124mm)
CASING INSTALLED	: None
WATER LEVEL	: Not Encountered

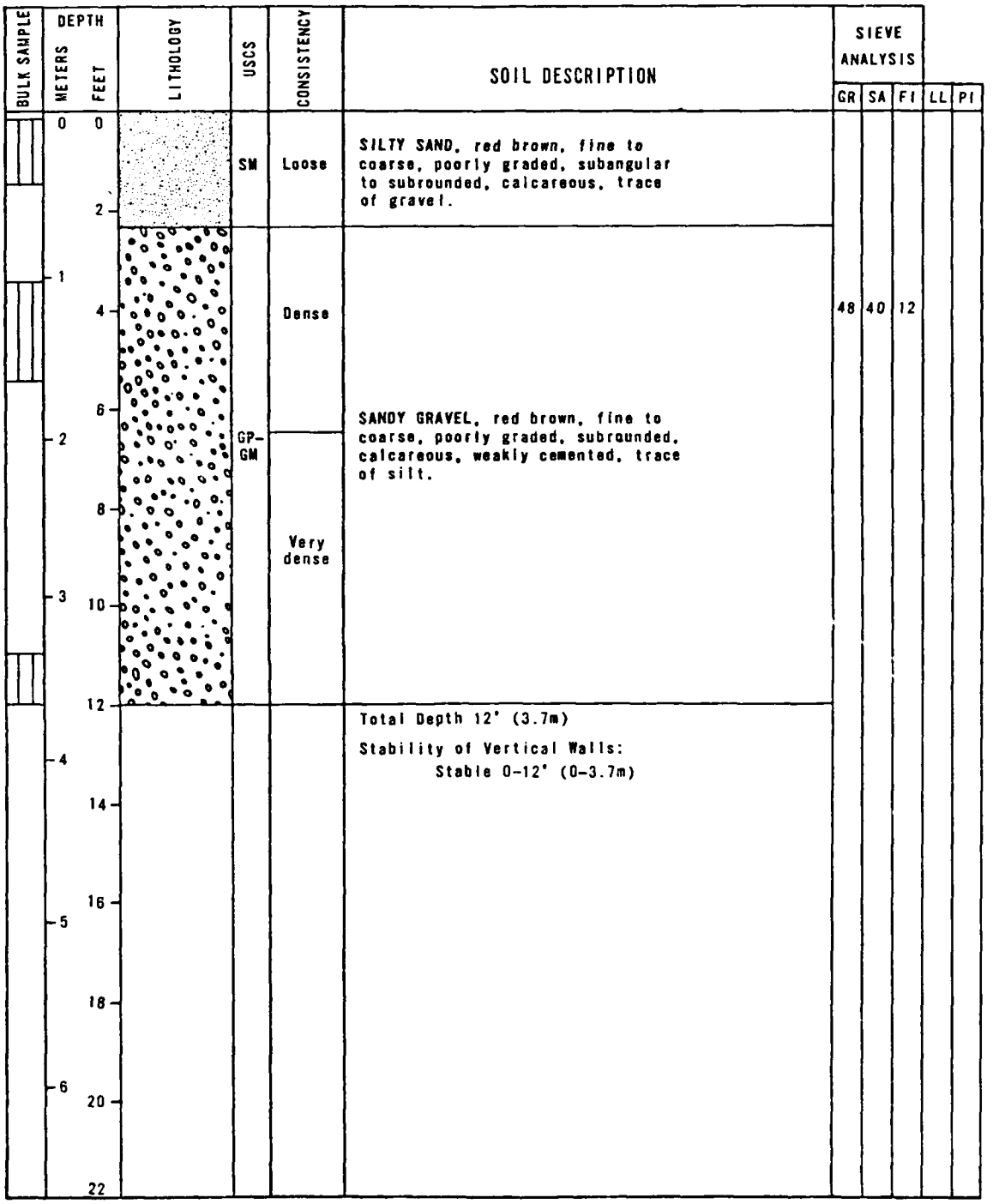
FUGRO NATIONAL, INC.

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

LOG OF BORING SV-B-12
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

FIGURE D-3

FN-TR-26e



TRENCH DETAILS

SURFACE ELEVATION : 2520' (768m)
DATE EXCAVATED : 30 January 1978
SURFACE GEOLOGIC UNIT : A5i
TRENCH LENGTH : 29.5'
TRENCH ORIENTATION : N82E

LOG OF TRENCH SV-T-2
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
D-4

UGRO NATIONAL, INC.

LOGGED BY
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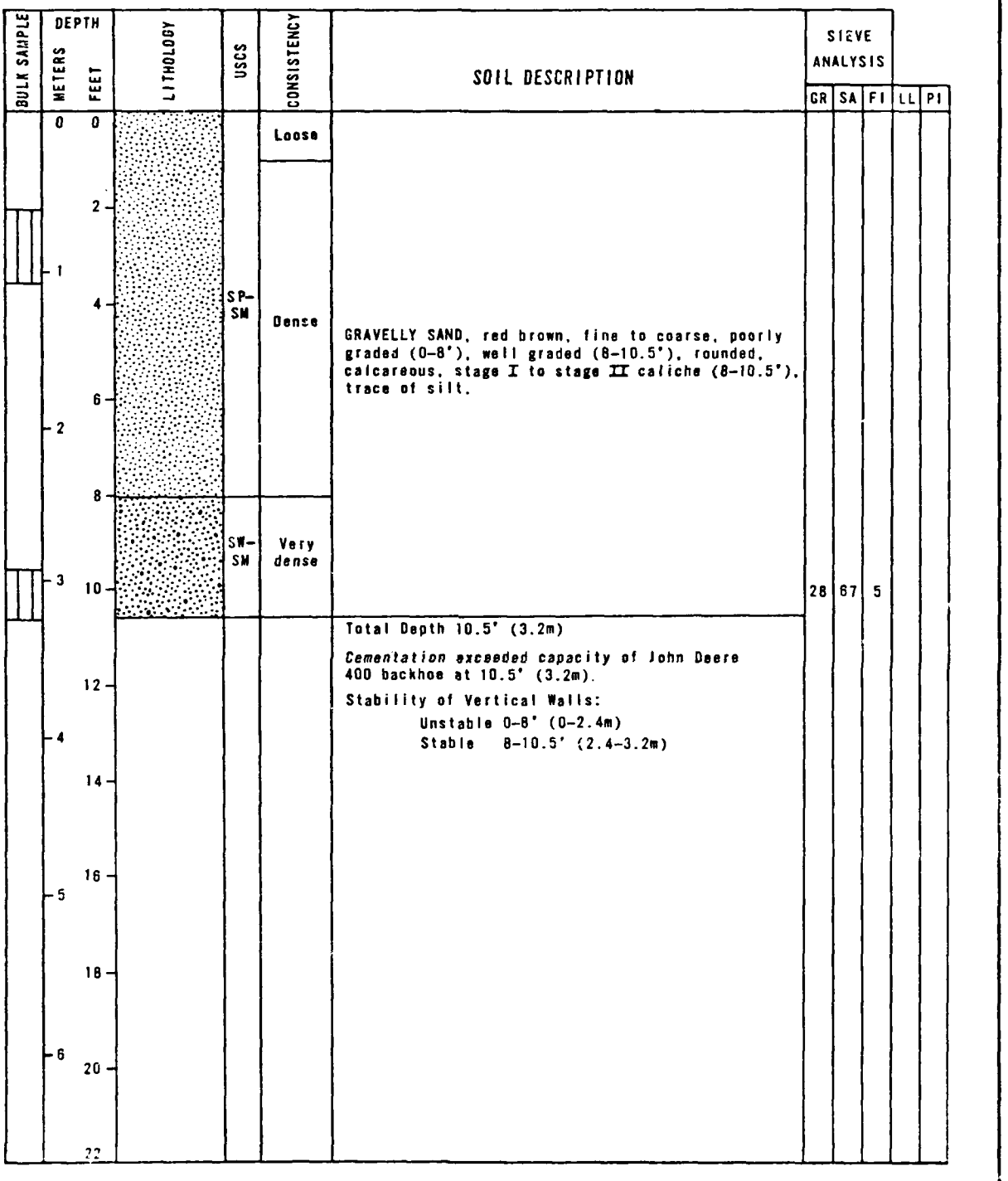
APPROVED BY

FN-TR-26a



TRENCH DETAILS

SURFACE ELEVATION	:	2500' (762m)
DATE EXCAVATED	:	31 January 1978
SURFACE GEOLOGIC UNIT	:	A5y, A5i
TRENCH DEPTH	:	27.8'
TRENCH ORIENTATION	:	N34E

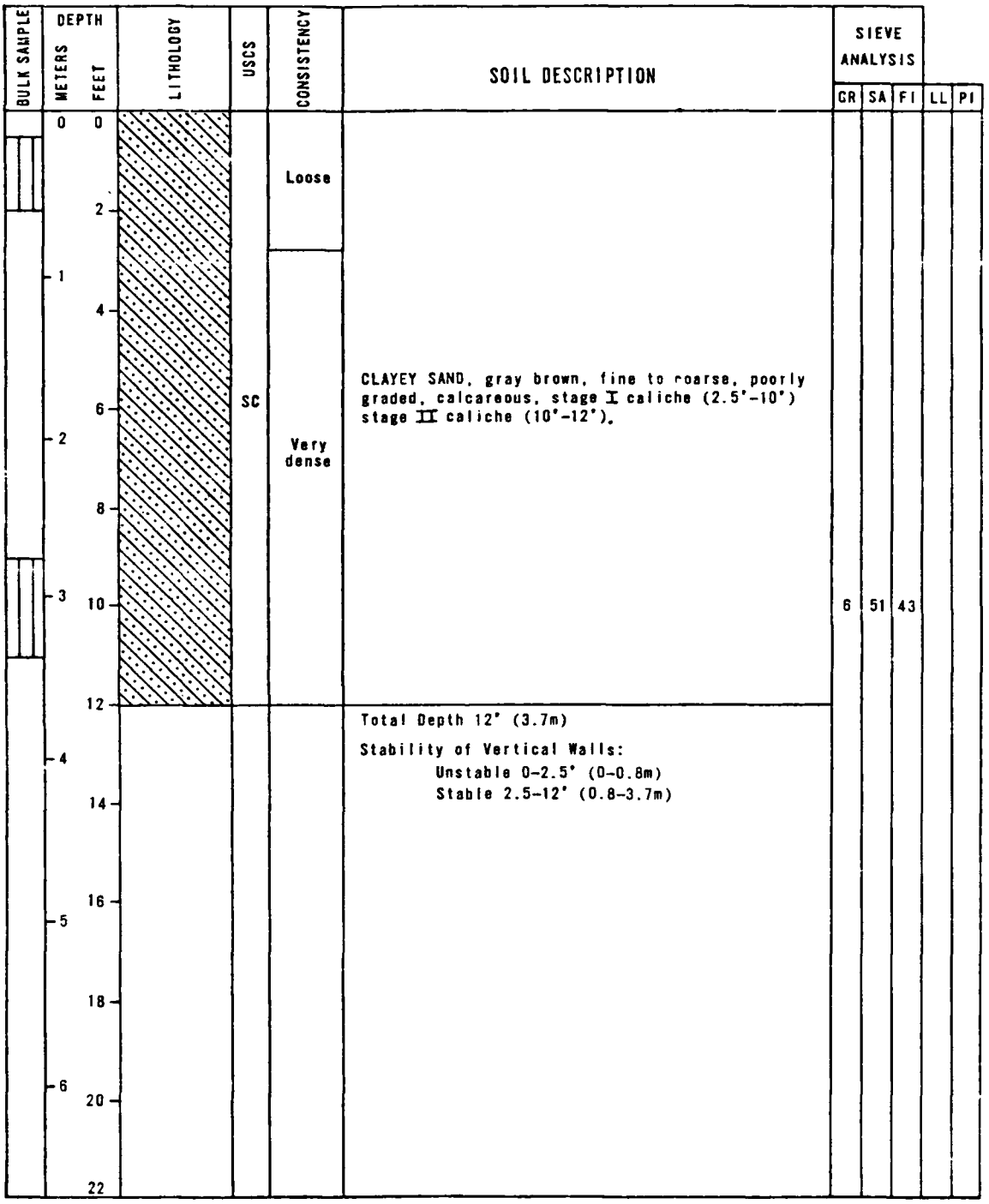
LOG OF TRENCH SV-T-6
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE - SAMSO

FIGURE
D-5

UGRO NATIONAL, INC.

FN-TR-26a



TRENCH DETAILS

SURFACE ELEVATION	:	2200' (671m)
DATE EXCAVATED	:	1 February 1978
SURFACE GEOLOGIC UNIT	:	A5y/A5i
TRENCH LENGTH	:	28.2'
TRENCH ORIENTATION	:	N35W

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LOG OF TRENCH SV-T-10
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
D-6

UGRO NATIONAL, INC.

BORING NUMBER	SAMPLE NUMBER (a)	SAMPLE INTERVAL		PERCENT FINER BY WEIGHT											
				STANDARD SIEVE OPENING							U S STANDARD SIEVE NO				
				BLDRS.	COBBLES		GRAVEL				SAND				
		FEET	METERS	24"	12"	6"	3"	1½"	3 4"	3 8"	4	10	40	100	20
SV-B-12	D-1	2.7-3.4	0.82-1.04												
	D-3	5.7-6.4	1.74-1.95												
	D-4	10.2-10.9	3.11-3.32												
	P-5	15.0-16.5	4.57-5.03							100	92	69	33	16	1
	P-6	20.0-21.5	6.10-6.55												
	P-7	25.0-26.5	7.62-8.08												
	P-8	30.0-32.3	9.14-9.84							100	97	81	38	22	1
	P-9	40.4-41.8	12.31-12.74												
	P-10	50.3-52.3	15.33-15.94												
	P-11	61.0-62.1	18.59-18.93						100	97	92	74	36	22	1
	P-12	71.0-72.5	21.64-22.10												
	P-13	81.0-81.7	24.69-24.90												
	P-14	90.0-91.4	27.43-27.86												
	D-15	100.2-100.9	30.54-30.57												
	P-16	125.0-126.3	38.10-38.50							100	98	78	37	23	1
	P-17	150.0-151.5	45.72-46.18												
	D-18	175.2-175.9	53.40-53.61												
	P-19	200.0-200.8	60.96-61.20												
	P-20	226.0-227.2	68.88-69.25						100	97	95	82	29	11	
	P-21	250.0-250.8	76.20-76.44												
	P-22	300.5-301.3	91.59-91.84							100	93	73	36	15	
	D-23	301.7-302.4	91.96-92.17												

NOTES:

(a) Sample types
- SS - Standard split spoon
- P - Pitcher
- D - Fugro Drive
- B - Bulk

(b) NP - Not Plastic

(c) USCS - Unified Soil Classification System

* Indicates that test has been performed and results are included in this report.

APPROVED BY

CHECKED BY

SIEVE NO		PARTICLE SIZE (mm)		ATTERBERG LIMITS (b)			USCS (c)	IN-SITU					COMPACTED			SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION
	SILT OR CLAY							DRY UNIT WEIGHT		MOISTURE CONTENT (%)	SATURATION (%)	VOID RATIO	MAXIMUM DRY DENSITY		OPTIMUM MOISTURE (%)					
100	200	.005	.001	LL	PL	PI		(pcf)	(kg/m³)				(pcf)	(kg. m³)						
							SC	106.6	1708	4.0	18.8	0.58								
							SC	111.5	1786	4.3	22.7	0.51								
							SC	113.3	1815	3.9	21.4	0.49								
16	1[illegible]						SP-SC	110.0	176[illegible]	7.2	35.4	0.54					**			
							SP-SC	132.2	2118	6.0	60.9	0.28								
							SP-SC	128.3	2055	8.5	73.1	0.31								
[illegible]	16						SM	114.7	1837	6.7	38.8	0.47							***	
							SC	114.4	1833	5.7	32.5	0.47								
							SP-SC	117.8	1887	8.8	55.3	0.43								
[illegible]	17						SC	105.6	1692	6.7	30.5	0.60								
							SC	116.5	1866	6.8	41.1	0.45								
							SC	123.7	1982	5.6	42.1	0.36								
							SC	123.3	1975	7.8	57.3	0.36								
							SM	122.7	1966	6.2	44.7	0.37								
23	16	4	1				SC	119.2	1910	6.1	39.6	0.41				2.67			*	
							SC	120.3	1927	6.4	43.4	0.40								
							SC	127.5	[illegible]	7.6	63.9	0.32								
							SC	124.5	1994	7.2	55.3	0.35								
11	7						SW-SM	122.7	[illegible]	5.3	38.7	0.37								
							SW-SM	123.9	1985	5.3	40.3	0.36								
1[illegible]	9						SW-SM	11[illegible].4	1[illegible]3	8.7	57.[illegible]	0.41								
							SW-SM	125.9	2017	8.2	65.3	0.34								

SUMMARY OF LABORATO
BORING SU
SACRAMENTO VALLEY, ARIZ

MX SITING INVESTIGA
DEPARTMENT OF THE AIR FOR

[illegible]

(%)	SATURATION (%)	VOID RATIO	COMPACTED: MAXIMUM DRY DENSITY (pcf)	COMPACTED: MAXIMUM DRY DENSITY (kg/m³)	OPTIMUM MOISTURE (%)	SPECIFIC GRAVITY OF SOLIDS	TRIAXIAL	UNCONFINED COMPRESSION	DIRECT SHEAR	CONSOLIDATION	CHEMICAL	RELATIVE DENSITY
	1[illegible]	0.58										
	[illegible].7	0.51										
	[illegible].4	0.49										
	[illegible].4	0.54					**					
	60.3	0.28										
	73.1	0.31										
	[illegible]	0.47							***			
	[illegible]	0.47										
	[illegible].3	0.43										
	30.[illegible]	0.60										
	41.1	0.45										
	[illegible].1	0.36										
	57.3	0.36										
	44.7	0.37										
	[illegible]	0.41				2.67			*			
	43.4	0.40										
	[illegible]	0.32										
	36.3	0.35										
	[illegible].7	0.37										
	40.3	0.36										
.7	[illegible]	0.41										
	65.3	0.34										

SUMMARY OF LABORATORY TEST RESULTS
BORING SV-B-12
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE D-1

FUGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	TYPE OF TEST	DRY DENSITY		MOISTURE CONTENT	CONFINING PRESSURE (σ_3)		MAXIMUM DEVIATOR STRESS ($\sigma_1-\sigma_3$)		STRAIN RATE	BACK PRESSURE	
		FEET	METERS			pcf	kg/m³	(%)	ksf	kN/m²	ksf	kN/m²	(% min)	ksf	kN/m²
SV-B-1	P-5	15.0-15.7	4.57-4.79	SC	CD	120.3	1927	10.4	4	192	39.5	1891	.10	0	0
		15.7-16.4	4.79-5.00	SC	CD	120.3	1927	7.8	2	96	26.0	1245	.10	0	0
	P-6	20.0-20.7	6.10-6.31	SM	CD	110.6	1772	5.7	8	383	27.5	1317	.10	0	0
SV-B-5	P-11	50.0-50.6	15.24-15.42	SM	CD	107.6	1724	7.5	6	287	20.2	967	.10	0	0
		50.6-51.2	15.42-15.61	SM	CD	111.0	1778	5.9	12	575	46.5	2226	.10	0	0
SV-B-10	D-7	25.2-25.9	7.68-7.89	SP-SC	CD	114.3	1831	9.1	3	144	16.1	771	.10	0	0
	D-10	49.2-49.9	15.00-15.21	SW-SM	CD	118.4	1897	5.7	6	287	30.0	1436	.10	0	0
SV-B-12	P-5	15.0-15.5	4.57-4.72	SP-SC	CD	107.0	1714	5.2	2	96	8.1	388	.10	0	0
		16.0-16.5	4.88-5.03	SP-SC	CD	108.8	1743	7.1	8	383	28.3	1355	.10	0	0

SUMMARY OF TRIAXIAL SHEAR TEST RESULTS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

TABLE D-2

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FUGRO NATIONAL, INC.

BORING NO.	SAMPLE NO.	SAMPLE INTERVAL		SOIL TYPE	NORMAL STRESS		MAXIMUM SHEAR STRENGTH	
		FEET	METERS		ksf	kN/m^2	ksf	kN/m^2
SV-B-1	P-9	35.0-35.7	10.67-10.88	SP-SM	4	192	3.4	163
					6	287	6.0	287
					8	383	6.6	316
SV-B-5	D-5	15.2-15.9	4.63-4.85	SC	2	96	2.4	115
					4	192	3.6	172
					8	383	9.4	450
SV-B-7	D-5	15.4-16.1	4.69-4.91	SM	2	96	3.4	163
					4	192	5.6	268
					8	383	10.3	493
SV-B-10	D-4	13.7-14.4	4.18-4.39	SP-SM	2	96	2.0	96
					4	192	3.8	182
					8	383	6.6	316
SV-B-12	P-8	31.0-31.7	9.45-9.66	SM	3.5	168	3.6	172
					7	335	8.5	407
					10.5	503	9.9	474

SUMMARY OF DIRECT SHEAR TEST RESULTS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE D-3

UGRO NATIONAL, INC.

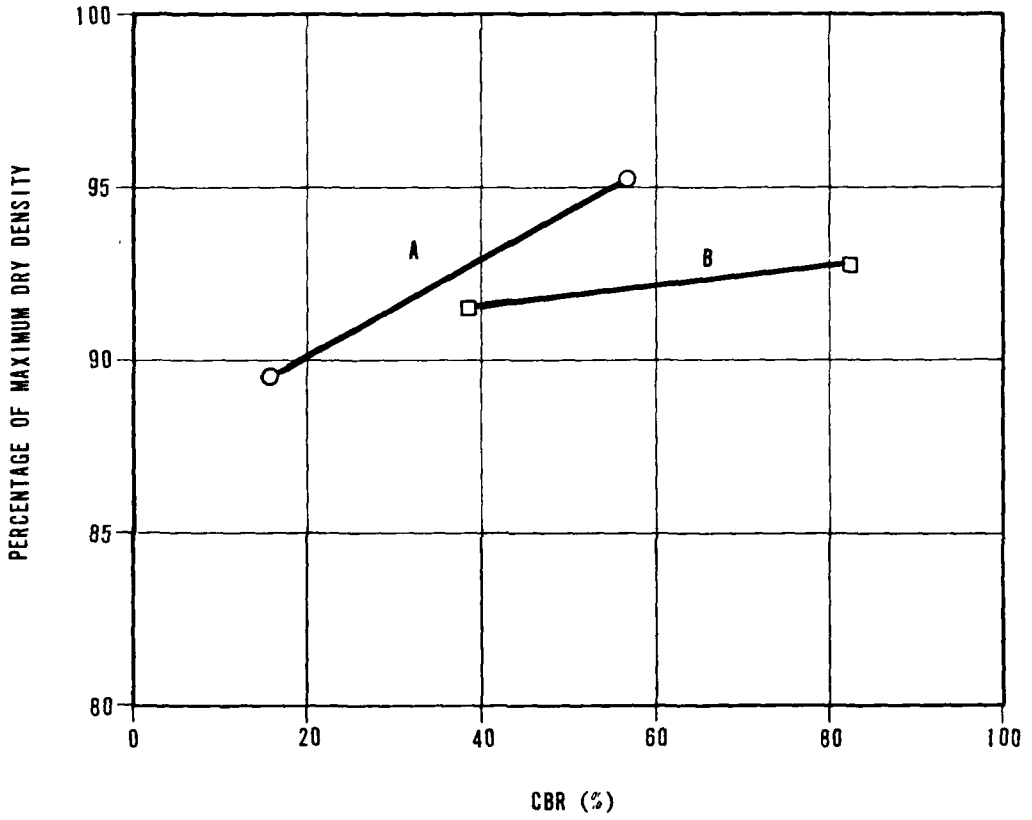
COMPOSITE SAMPLE NUMBER	SOIL TYPE	PERCENT PASSING #200	ATTERBERG LIMITS LL	ATTERBERG LIMITS PI	SPECIFIC GRAVITY	MAXIMUM DRY DENSITY pcf	MAXIMUM DRY DENSITY kg/m³	OPTIMUM MOISTURE (%)	COMPACTED DRY DENSITY pcf	COMPACTED DRY DENSITY kg/m³	COMPACTED MOISTURE (%)	PERCENT OF MAXIMUM DRY DENSITY	CBR (%)
A	SC	25				119.5	1914	11.5	113.6	1820	11.7	95.1	57
									107.0	1714	11.3	89.5	16
B	SP-SM	10				131.1	2100	8.0	123.0	1970	8.1	93.8	82
									119.8	1913	8.3	91.4	39

CALIFORNIA BEARING RATIO
(CBR) TEST RESULTS
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

TABLE
D-4

UGRO NATIONAL, INC.



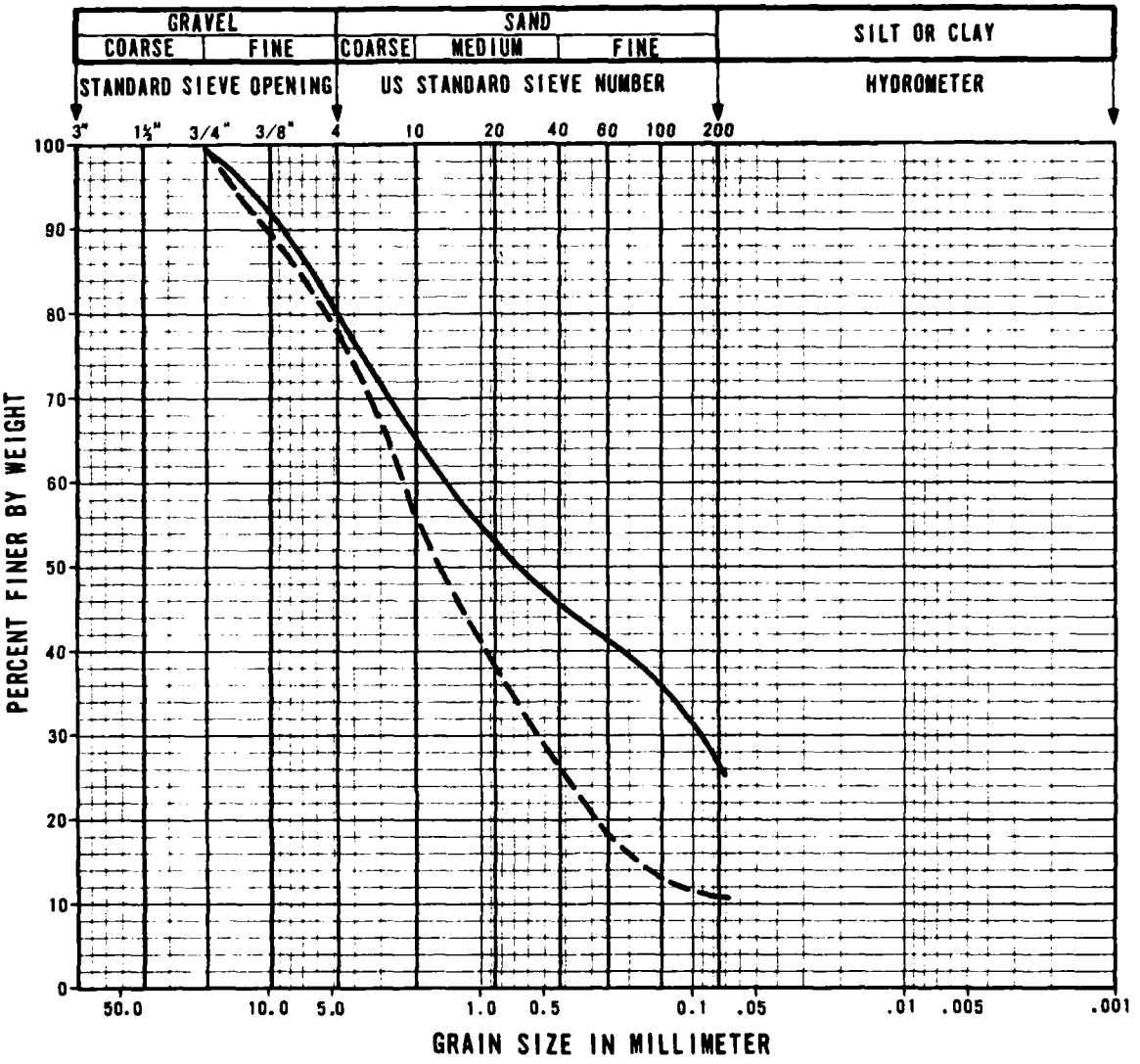
SYMBOL	COMPOSITE SAMPLE NUMBER	SOIL TYPE
○	A	SC
□	B	SP-SM

CALIFORNIA BEARING RATIO
(CBR) CURVES
SACRAMENTO VALLEY, ARIZONA, GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
D-7

UGRO NATIONAL, INC.



SYMBOL	COMPOSITE SAMPLE NUMBER	TRENCH NUMBER	SAMPLE INTERVAL		SOIL TYPE
			FEET	METERS	
——	A	SV-T-7	6.0 - 8.0	1.8 - 2.4	SC
		SV-T-12	5.0 - 6.6	1.5 - 2.0	
– –	B	SV-T-6	3.5 - 6.5	1.1 - 2.0	SP-SM
		SV-T-2	9.5 - 10.5	2.9 - 3.2	

GRAIN SIZE CURVES, CBR TESTS
SACRAMENTO VALLEY, ARIZONA
GREAT BASIN CSP

MX SITING INVESTIGATION
DEPARTMENT OF THE AIR FORCE SAMSO

FIGURE
D-8

FUGRO NATIONAL, INC.

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